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THE HABITS OF THE EUCHARIDÆ

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From many points of view the Eucharidæ are the most interesting of the families of Hymenoptera of parasitic habit. Though world-wide in distribution their habits and host relationships are little known. Studies thus far made have shown a parallelism in habit and development with the Perilampidæ, though revealing an even higher degree of specialization and greater variations between species. Accounts are being presented elsewhere of the oviposition habits and on the morphology of the immature stages of the family, and the present article deals principally with the host preferences and the habits of the adults and larvæ.

Host Preferences

All species of Eucharidæ are, so far as known, parasitic upon the mature larvæ or pupæ of ants. The host preferences of the species observed by the writer, so far as they were determined, are as follows:

Species	*Host**	*Country*
Chalcura deprivata (Walk.)	*Odontomachus hæmatodes* L.	Ceylon
Kapala terminalis Ashm.	*Odontomachus hæmatodes insularis pallens* Wheeler	Cuba
Kapala sp.	do.	Cuba
Eucharis scutellaris Gahan	*Formica fusca fusca japonica* Mots.	Chosen
Schizaspidia convergens (Walk.)	*Odontomachus hæmatodes* L.	Ceylon
Stilbula tenuicornis (Ashm.)	*Camponotus herculeanus japonicus* Mayr.	Japan
	Camponotus herculeanus ligniperdus obscuripes Mayr.	Chosen

*Determinations by W. M. Mann

Wheeler and Wheeler, in 1937, compiled the records of host preferences published up to that date, and their list comprises 31 species, of 15 genera. The questionable generic assignment of many species makes it difficult to summarize generic preferences, but 4 species of *Orasema* are recorded only from *Pheidole,* 1 from *Solenopsis,* 1 from both these genera, and 1 from *Wasmannia. Eucharis* has been reared from *Messor, Cataglyphis, Myrmecia,* and *Formica.* Three species of *Stilbula* are known to parasitize *Camponotus,* while species of *Chalcura, Kapala,* and *Rhipipallus* have been reared from several subspecies of *Odontomachus hæmatodes.* Considering that the larval and pupal stages of most of the castes of the different species of ants known to be parasitized by Eucharidæ are usually of sufficient size to bring the parasites to maturity, we might assume that they will all be subject to attack. The available evidence, however, indicates that in some species certain castes are exempt, and these are not the same among different species. Wheeler (1907) states that only the soldiers, males, and females of *Pheidole instabilis* Emery are parasitized by *Orasema,* as the workers are too small to provide sufficient food for the larvæ of the parasite. He also indicates that the single worker form of *Solenopsis validiuscula* Emery is immune to attack by *O. coloradenis* Wheeler for the same reason.

In his studies on *Stilbula cyniformis* Rossi, Parker (1932) noted that attack was limited to the large-headed wingless workers and to the winged forms of the same size, which are presumed to be the males.

An examination of the immature stages found in the nest of *Odontamachus hæmatodes* in the Botanical Garden at Peradeniya, Ceylon, indicated that only the slender, small-headed pupæ were parasitized by *Chalcura deprivata,* whereas *Schizaspidia convergens* developed also upon the pupæ of the larger workers having very large heads and long and heavy mandibles. These latter comprised a large portion of the host population.

Sufficient information is not yet available to explain the above limitations of eucharid attack to certain host castes. Even in *Solenopsis validiuscula,* mentioned above, where size is assumed to be the determining factor, some other cause may well be responsible. It is known that many parasitic insects possess a great adaptability in respect to the quantity of food required to bring them to maturity, and because of this some adults of certain species are as much as fifty times as large, by volume, as others.

Habits of the Adults

The adults emerge from the ant nest during the morning hours, the males usually slightly preceding the females, and mating takes place almost immediately. Swarms of males of *Stilbula tenuicornis*, numbering 100 or more, have been observed hovering in the air 1 or 2 feet above the entrance to a *Camponotus* nest (Clausen, 1923). As the females appeared at the entrance to the burrow they were pounced upon before they could take flight. A similar congregation of males over the host nest has been noted in *Eucharis scutellaris*. The stimulus which attracts these males to the host nest is not known; it may be the nest odor, or they may be able to detect the presence of the freshly-emerged females of their own species in the nest. Not all species show this extreme agitation and activity on the part of the males. Those of *Kapala terminalis* rest quietly upon foliage nearby and become active only when a female emerges from the host burrow.

Wheeler (1926) records the observations of W. M. Mann on a species of *Orasema*, five males of which were found mating with female pupæ in an ant nest.

The ants of the host colonies usually pay very little attention to the eucharid parasites following transformation of the latter to the adult stage, though Wheeler mentions that *Pheidole* workers carry the adults of *Orasema* about in the nest and even feed them. Field observations on *Eucharis scutellaris* revealed many freshly emerged adults being dragged about over the ground by *Formica* workers, evidently in an effort to carry them back into the nest.

Observations indicate that the adults of the majority of species do not feed. The entire quota of eggs in the ovaries is fully developed at the time of emergence of the adult female, and in many species these are all deposited that same day, so there is little need for food. Females of *Kapala furcata* (F.) of Panama were observed upon foliage heavily infested with aphids and apparently they were feeding upon honeydew. This was noted only during the afternoons and was upon a plant species different from that utilized for oviposition earlier in the day.

The oviposition habits of the Eucharidæ are extremely varied but in no instance are the eggs laid in the nest of the host. They may be placed in masses in overwintering buds of trees, in expanding leaf and flower buds, or in seed receptacles or pods, singly or in small groups in incisions in leaf tissue, or at random upon the surface of leaves. One species, *Psilogaster antennatus* Gahan, oviposits on the leaf surface only in the immediate vicinity of a freshly deposited thrips egg.

The obligatory inclusion of one or more plant species, for oviposition purposes, in the economy of each species of Eucharidæ serves as a very definite check upon its local distribution. The presence or absence of the required oviposition plants directly governs distribution, and this, in many instances, is much more of a limiting factor than is host distribution or abundance. It is because of this that eucharid colonies are almost invariably of small size and widely separated. Each of the species which has been studied is known through definite colonies of very limited extent rather than of general occurrence in a locality. The several species found in the Botanical Gardens at Peradeniya, Ceylon, which are all parasitic on *Odontomachus*, were found to infest only the ant colonies situated immediately beneath the trees in which the eggs are laid. This is believed to be due to the members of these colonies monopolizing the areas in which their nests are situated. The exclusion of ants from other nests prevents their coming in contact with planidia on the surface of the ground beneath the trees, and consequently these latter are not transported to more distant nests.

The distribution of a eucharid parasite is thus controlled by a factor which may have no influence upon the host itself and, as a result, the latter may be entirely free from attack over the greater part of its range. The Eucharidæ are therefore relatively minor influences in the natural control of ants. Even within the colony limits the parasitization is relatively low. The colony of *Stilbula tenuicornis* under observation at Koiwai, Japan, showed a maximum parasitization of 47 percent in a single nest in 1921. A total of approximately 10 million eggs, over 4 million of which were in a single tree, were deposited that season in an area about 100 yards square, yet in 1922 the resultant maximum parasitization declined to 16 percent.

The study of the biology and habits of the Eucharidæ was long handicapped by difficulties in associating the oviposition habits of the females with the immature stages in the ant nests. Sufficient is now known regarding the general habits of the family so that, in most cases, the infested nest can be found if a female can be found or captured or, if the infested nest from which adults are emerging is first found, the oviposition habit can be quickly determined. The females are intent upon oviposition immediately after emerging from the nest and, as they fly very slowly and can be readily kept in view, they can be followed and their method of oviposition observed. This normally takes place within 1 hour after emergence and often almost immediately.

If adult females have been captured or observed, the host nest can be located without difficulty. These females are usually limited to a radius of not exceeding 50 feet from the nest, and they fly no farther than is necessary to reach a tree or plant suitable for oviposition. In many species the actual nest entrance can be detected by the swarm of eucharid males hovering over it. In other cases the size of the parasites greatly restricts the number of possible hosts, so a relatively small number of nests need be examined definitely to establish the association. *Chalcura deprivata* and *Schizaspidia convergens* of Ceylon and *Kapala terminalis* and *Kapala* sp. of Cuba are all parasites of *Odontomachus*. A consideration of the size of the adults observed ovipositing in trees, and of the ant species present in the immediate vicinity, indicated that *Odontomachus* was the only one present of sufficent size to accommodate the parasites. In each case the first nest that was excavated confirmed the conjecture that this was the host.

Habits and Development of the Immature Stages

During the course of incubation the eggs change in color from the original translucent white to deep amber, this being due to the pigmentation of the skin of the developing embryo. In some species, notably *Stilbula cyniformis*, there is a distinct bluish reflection in the older eggs. The egg stalk, of course, retains its original color.

The very incomplete information on the habits of the planidia during their free-living period indicates that they attach themselves to worker ants and are thus carried into the nest, where they transfer to the larvæ. Those of *Stilbula tenuicornis* were found upon the twigs and foliage of aphid-infested plants frequented by worker ants in their search for honeydew. In the alert position they stand erect upon the caudal sucker and the body is braced by the long spines of the posterior abdominal segment and by the spinelike projections of the pleural plates. They quickly attach themselves to any moving object that comes within reach.

In the study of *Kapala terminalis* and *Kapala* sp. in Cuba it was found that the planidia have a highly developed capacity for jumping. They stand erect upon the caudal sucker and, without any distinguishable preliminary movements, hurl themselves into space. The horizontal distance covered is about 10 millimeters, which is approximately one hundred times their own body length. This habit, if general in the family, would explain how *Parapsilogaster læviceps* Gahan and *Kapala terminalis*, which oviposit in incisions in leaves, reach their hosts. In their foraging the *Odontomachus* workers do not ascend trees and consequently, if the parasite planidia remained upon the foliage, they would have no opportunity to attach themselves to an ant carrier and be transported into the nest. By jumping they reach the ground, where they may encounter worker ants of the host species.

The intervention of a carrier other than the adult of the host species is apparently obligatory in *Psilogaster antennatus* Gahan. The eggs of the parasite are deposited on the leaf surface only in the immediate vicinity of an egg of *Selenothrips rubrocinctus* (Giard), and the eggs of the two species hatch simultaneously. As the thrips larva scrambles about among the erect eggs of *Psilogaster* the planidia of the latter attach themselves to it and are carried away. They remain attached by their mandibles to the thrips larva, but without noticeable feeding, until its first molt, when they disappear. One young larva collected in the field carried 53 planidia upon its body, yet did not seem to be inconvenienced thereby. These thrips are not attended by ants nor is the host of the parasite known, so the significance of this relationship cannot yet be determined.

Stage of the Host Which Is Attacked

Because of the habits of the planidia, which are carried into the nests by the adult ants, it is assumed that that transfer is effected mainly, if not entirely, to the ant larvæ rather than to the pupæ. This would seem to be obligatory in attack upon hosts which pupate in cocoons. In all species which have been studied the parasite planidia have been found upon the larvæ, even though development may not take place upon this stage. The majority of species permit the host to attain the perfect pupal form before death. Wheeler found that feeding by the larvæ of *Orasema* was upon the prepupæ and that the host never attained the typical pupal form. He designates the deformed host pupæ, with reduced heads and appendages, as phthisergates, while depleted semipupæ of females and males, such as result from attack of *Orasema* upon *Pheidole instabilis*, are designated as phthisogynes and phthisaners, respectively. The abstraction of a portion of the body fluids has halted the development of these individuals and they eventually die. *Schizaspidia convergens* also kills its host in the prepupal stage and the antennal sheaths never extend beyond the middle of the thorax.

There are a number of variations in habit of the immature stages of the species which develop ectoparasitically. These relate to the position of the larva on the host body, the stage of its development at the time of transfer to the host prepupa, and the time at which death of the host takes place. After the planidia reach the host larvæ in the nest they attach themselves within a relatively limited area on the body. Those of *Kapala terminalis* are invariably found laterally on the throat, while *Stilbula tenuicornis* and *Schizaspidia* are found there or in one of the sutures between the thoracic segments. Occasional individuals attach themselves to the abdomen.

In the earlier account of the biology of *Stilbula tenuicornis* it was pointed out that the planidium feeds and attains its full growth while still upon the *Camponotus* larva, and that the first molt takes place just as the host is transforming to the pupal stage. The newly-formed second-instar larva makes its way from the larval skin of the host as soon as the latter is freed from the prepupa at the point of attachment of the parasites and it then takes up a feeding position, constant for the species, on the pleural region of the metathorax, beneath a wing pad, or beneath one of the hind legs, of the pupa. The exuviæ of the planidium remains attached to that of the host larva and is found with it at the base of the cocoon. This is the only species known to undergo the first molt prior to transfer to the host pupa. *Orasema wheeleri* Wheeler, *S. cyniformis, Chalcura deprivata, Eucharis scutellaris,* and *Kapala* sp. are still first-instar larvæ at the time of the host molt. The planidia of *Kapala* sp. are fully fed and consequently fully distended at this time, whereas those of *C. deprivata* and *E. scutellaris* show no increase in size or separation of the segmental bands, and they presumably do not feed extensively until the host pupa is reached.

The increase in size of the planidium before the first molt is relatively enormous, and Parker (1932) mentions an increase of 1,000 times in *Stilbula cyniformis.* In *Schizaspidia convergens* the body length is approximately 1 millimeter as compared with one-tenth that length for the newly hatched individuals, and the increase in volume approximates the figure given by Parker. There was some doubt that this larva was actually the first instar, rather than the early second with the exuviæ still enveloping the body. Upon close examination, however, the mandibles of the heavily sclerotized first-instar head were seen to move, and when the larva was removed from the host and then replaced the mandibles were again imbedded in the skin.

As soon as the larva, in either its first or early second stage, becomes attached to the host prepupa or pupa its feeding and consequent growth are exceedingly rapid. Only a single feeding puncture is made, and in *Stilbula tenuicornis, Schizaspidia convergens, Kapala terminalis* and *Chalcura deprivata* the contents of the host pupa are completely sucked out, leaving only the white collapsed skin. According to Parker this occurs also in *Stilbula cyniformis*. Wheeler has pointed out that the *Orasema* larva consumes only a portion of the body contents of the *Pheidole* prepupa, and that the latter may still be alive after the completion of feeding by the parasite. *Eucharis scutellaris* likewise only partially exhausts the available food supply in the host body, though death of the host occurs before the parasite larva is mature.

The complete consumption of the pupal contents by several species indicates an appreciable amount of preoral digestion. It is improbable that suctorial action alone, through a single minute feeding puncture, could accomplish such a complete withdrawal of the body contents without a more thorough liquefaction than normally takes place during the period covered by the feeding of the third-instar parasite.

Parker has called attention to the apparently complete lack of tegumentary muscles in the mature larva of *Stilbula cyniformis*, and states that no indication of muscular action could be detected at any time. The same is true of *S. tenuicornis*, but in several of the other species mentioned above feeble contractions were observed in the younger larvæ of this stage. In no instance was there any movement of the body as a whole.

When the mature larvæ are examined it is found that the cast skins are present and adhere closely in a characteristic way. In all species examined, with the exception of *Stilbula tenuicornis*, the two adhere ventrally to the thoracic and anterior abdominal segments. They are readily recognizable because of the darkened segmental bands of the first exuviæ. The line formed by these widely separated bands is transverse in *Chalcura deprivata* and diagonal in *Schizaspidia convergens* and *Eucharis scutellaris*. The head of the first exuviæ is detached and remains fixed in the feeding puncture in the skin of the host pupa. In *Schizaspidia tenuicornis* only the second exuviæ are present in this position, as the first are cast before pupation of the host and remain attached to the larval skin of the latter.

In the majority of species which develop upon hosts that form cocoons prior to pupation, the remains of the host prepupa or pupa are found as a deflated envelope upon which the parasite pupa lies. There is no crumpling of the remains into a mass, and the parasite pupa occupies the same position as that previously held by the feeding larva. However, the remains of *Odontomachus* pupæ which have died as a result of attack by *Chalcura deprivata* or *Schizaspidia convergens* are found in a crumpled mass at the posterior end of the cocoon. In these species the mature larva is capable of only feeble muscular contractions, although these may be sufficient to push the host remains into the position mentioned.

Incomplete information indicates that all Eucharidæ normally develop as solitary parasites, though the quantity of food material available may be sufficient to bring several to maturity. In a number of species it has been noted that an occasional host cocoon contains two parasite individuals, one on each side of the parasitized pupa. Thus the solitary habit is not obligatory, though the number of exceptions to this habit is small when compared with the number of host larvæ which bear several planidia.

Endoparasitic Development in Orasema

One of the most surprising of the recent discoveries in the biology of the Eucharidæ is the endoparasitic mode of development of two species of *Orasema* (Wheeler & Wheeler, 1937). The first-instar larvæ, both unfed and fully distended, of *O. sixaolæ* W. & W. and *O. costaricensis* W. & W. were found within the bodies of different sized larvæ of *Solenopsis tenuis* Mayr and *Pheidole flavens* Roger var. in Costa Rica. They had evidently entered the host bodies by direct penetration of the skin and remained there with the posterior segments of the abdomen protruding from the entry hole. The fully distended planidia were found to lie with the dorsum immediately beneath the host skin, rather than free in the body cavity. The posterior portion of the body of these individuals is enveloped by a "collar" which projects inward from the periphery of the wound. This formation is apparently identical in origin with the respiratory funnel of the Tachinidæ, but its function is not so clearly indicated. These larvæ do not possess the posterior spiracles; in fact the presence of spiracles is not mentioned in the descriptions, and the occurrence of an open tracheal system in the planidia of this family is still debatable. The small size of the planidia would permit of cutaneous respiration, and sufficient air may possibly enter the opening of the funnel and surround the body to provide for their needs.

Eighteen planidia of *Orasema sixaolæ* and seven of *O. costaricensis* were found in the bodies of *Solenopsis* and *Pheidole* larvæ and none was found externally upon either larvæ or pupæ. The intermediate instars were not found but the mature larvæ of *O. costaricensis* occurred free in the nest. It is therefore not known whether the larvæ are endo- or ectoparasitic after the first molt.

The ectoparasitic manner of development of *Orasema* had been conclusively demonstrated by W. M. Wheeler in his early work (1907) upon *O. wheeleri* Wheeler[1] and others in Texas and Colorado, and later authors found the same habit in other genera. It was consequently believed that the habit was general in the family. It was doubly unexpected that the endophagous habit should appear in species which belong to this same genus and are parasitic upon the same genera of hosts.

Another feature in the biology of the two species of *Orasema* above mentioned is that they appear to be strictly larval parasites, whereas other species of the family are known to complete their development only on the prepupa or pupa. The endophagous habit may be associated with the change in the host stage which is attacked. Somewhat similar differences in developmental habits are known in the related Perilampidæ.

The Life Cycle

The complete life cycle, with the duration of the different developmental stages, has been determined only for *Stilbula tenuicornis*. This species passes the winter and a large portion of the following season, representing an elapsed time of approximately 11 months, in the egg stage in the buds of trees. The larvæ are fully formed in the eggs within 20 days after deposition and they then remain in diapause for the remainder of the period. The duration of the first larval stage is variable, depending upon the length of time from hatching to entry of the planidium into the host nest, after which it must await pupation of the host individual before proceeding with its own development. The second and third larval stages and the pupal stage are passed very quickly and require 3, 4 and 6 days, respectively.

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[1] According to A. B. Gahan (U. S. Natl. Mus. Proc. 88: 425-458, 1940) the biological data presented by Wheeler under *Orasema viridis* Ashm. relate to *O. wheeleri* instead.

The incomplete data presented by Parker (1937) on *Stilbula cyniformis* indicate that its cycle may be similar to that of *S. tenuicornis*. Adults are present only during August and the females oviposit in the seed receptacles of *Picris*. The egg masses are blown away with the seeds a short time later and they may not hatch until the following spring.

Practically all the species found in distinctly temperate regions have only a single generation each year. *Eucharis scutellaris* of Chosen, which appears in the adult stage only during June, oviposits in flower buds, and the incubation period is only 15 days. In 1928 an examination of the colony site on June 4 revealed no adults, but these were present in numbers on June 7. A large quantity of *Formica* cocoons, comprising those of both the large females and the smaller workers, was collected on the latter date. In the large cocoons all parasites except two were in the pupal stage, and these two were prepupæ. In the worker cocoons, however, the hosts had not yet transformed to pupæ and their parasites were consequently in the first larval stage. There being only one generation per year, it appears that the winter must have passed by all individuals in the first larval stage upon the ant larvæ.

A similar annual cycle is followed by *Orasema coloradensis* in Virginia. Oviposition occurs only during July, and the eggs hatch in less than 2 weeks. In the tropics the cycles of the species of the various genera observed are much shorter, probably not exceeding 1 month, and adults are present throughout the year if climatic conditions are favorable. The incubation period of *Schizaspidia convergens* of

Ceylon and *Kapala* sp. of Cuba is 10 to 14 days, while Ishii (1932) states that it is only 1 week for *Kapala foveatella* Gir., *Parapsilogaster montanus* Gir., and *Losbanos uichancoi* Ishii in the Philippine Islands.

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METAMORPHOSES OF CUBAN NYMPHALIDÆ AND LYCAENIDÆ[1]

By V. G. Dethier
John Carroll University, Cleveland, Ohio

This paper is intended to supplement an earlier communication on the immature stages of Cuban diurnal Lepidoptera (Dethier, 1940). The three species of Nymphalidæ and single species of Lycænidæ described below are four very common members of the Cuban fauna. Nevertheless, their early stages and oviposition habits are but imperfectly known.

Precis zonalis Felder & Felder

Egg. Biscay green. Height .75 mm. Greatest diameter .65 mm. Eleven raised longitudinal ribs. In general appearance the egg resembles those of species of *Anartia.* It is nearly round but seems squat due to the fact that the base is perfectly flat and the section of greatest diameter is nearer the base than the apex. The ribs are raised a greater height from the surrounding surface at the apex than elsewhere. The surface of the egg applied to the plant is made up of microscopic polygonal areas.

First Instar. Head height .4 mm.; head width .4 mm. Smooth, shiny, and nearly black. There are a few long scattered hairs of the same color. The arrangement of these hairs is shown in Plate V Figure 1. The spherical nature of the head and the shallowness of the apex are also shown. Body 2.5 mm. long. Amber yellow. The transparency of the integument allows the green coloring of plant material in the gut to be seen. Few long scattered black hairs. Most of these are recurved forward. No branched spines are present in this instar. The thoracic legs are the same color as the head. Spiracles same color as body.

Second Instar. Head height .6 mm.; head width .6 mm. Shiny black. Same shape as in previous instar. Hairs more

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[1] This work was aided by a Harvard University Fellowship.

numerous. Body 4.5 mm. long. Amber yellow suffused with green dorsally. Large branched spines present. A mid-dorsal row of spines occurs on the abdominal segments. A para-dorsal row occurs on all segments but the first thoracic, a suprastigmatal row on the third thoracic and all abdominal segments, a substigmatal row on all segments but the first thoracic, and a prespiracular spine on the prothoracic segment. The thoracic spines are the largest. All spines and their spinules are black. All legs black. Spiracles amber yellow.

Third instar. Head height .8 mm.; head width .9 mm. Shiny black. Surface smooth. Black hairs more numerous. Two small spines at apex bearing two large spinules and several small ones. Head now much wider in appearance. The distribution and relative lengths of the hairs are shown in Plate V Figure 5. Body 6.5 mm. long. Legs black. Body deep slate-olive. On the first thoracic segment and at the bases of the suprastigmatal and substigmatal spines there is a suffusion of buff-yellow. There is a slight tendency toward the same on the dorsal side of the anal segment. Ventral surface buff-yellow. Spines black. Spiracles buff-yellow.

Fourth Instar. Head height .9 mm.; head width 1.1 mm. Head similar to the previous instar with the following exceptions: hair sockets yellow, clypeus yellow. Body 7.5 to 8 mm. long. Deep slate-olive dorsally. Abdominal legs and underside buff-yellow. Anal segment and prothoracic segment suffused with buff-yellow dorsally. Spines and spinules black. Arranged as in previous instar (cf. Plate VI Figure 7). Spiracles buff-yellow.

Eggs laid July 13 hatched three days later, July 16. Each instar required three days. The first moult took place July 19, the second July 22, and the third July 25. Eggs were laid on either side of the leaves of *Lippia*. The female usually came to rest on the top of small plants with the result that eggs were seldom found anywhere but at this position.

Anartia jatrophae jamaicensis Moeschler

Egg. Primrose yellow. Height .75 mm. Greatest diameter .60 mm. The egg of this species appears less squat than that of *A. lytrea chrysopelea* due to the fact that its height surpasses its diameter. There may be eleven or twelve longitudinal ribs. The same female may lay eggs of both types. In all other respects the eggs resemble those of the next species.

First Instar. Head height .3 mm.; head width .38 mm. Head shiny piceous. Nearly round. Few scattered black hairs. Plate V Figure 3 shows the locations and distribution of these hairs. Body 2 mm. long. Color before eating primrose yellow. After eating, parrot green. First abdominal segment orange. Body covered with scattered hairs arising from brown sclerites. Hairs long and microscopically serrate. Dorsally located hairs black. Forwardly recurved. Those below the subventral fold transparent and backwardly recurved. The distribution of the hairs dorsal to the subventral fold on the prothoracic segment is shown in Plate VI Figure 1. On the cervical shield are located four pairs of hairs. Three of these are in a transverse line on the anterior edge of the shield. The fourth is on the posterior edge. Ventral to the shield proper is a sclerite bearing two hairs directed downward. The more anterior one is longer. The prespiracular wart bears a single hair. In the subventral position are located two small transparent hairs of equal length. Both are directed downward. The arrangement of the hairs on the fourth abdominal segment is shown in Plate VI Figure 2. Hairs i, iii, and v are in a straight line and ii, iv, vi, vii, viii in a straight line on the posterior edge of the segment. v is ventral and slightly anterior to the spiracle. iv is directly posterior to the spiracle. Hairs i to v are long and conspicuous. Hairs vi to viii are minute. Spiracles same color as body. Rimmed with fuscous.

Second Instar. Head height .5 mm.; head width .55 mm. Head shiny piceous, nearly black. Region of ocelli black. Large branched spines on apex of head slightly lighter in color than the surrounding surface. Spine stouter and more swollen distally than in the next species. Plate V Figure 6 shows the arrangement of the hairs of the head in this instar. Body 3.75 mm. long. Parrot green. Now covered with large black branched spines. These are distributed as follows: a mid-dorsal row on all abdominal segments, a para-dorsal row on all segments (Plate VI Figure 6) but the prothoracic where there is a group of hairs, a suprastigmatal row on all segments, and a substigmatal row on all segments but the prothoracic. Here there is a prominent prespiracular spine. Spiracles same as before.

Eggs laid July 14 hatched four days later, July 18. The first instar required four days for completion; the second instar, four days. The food plant is *Lippia*.

Anartia lytrea chrysopelea Hbn.

Egg. Light chalcedony yellow. Height .60 mm. Greatest diameter .75 mm. The greatest diameter lies nearer the base than the apex. Eleven raisd longitudinal ribs. These project a greater height from the surrounding surface at the apex of the egg than elsewhere. In profile they present a serrated appearance. This is not so evident as in the egg of *Metamorpha stelenes insularis* (Holland). The ribs are joined by many microscopic parallel cross striations which at the apex of the egg form the micropyle rosette and at the base are replaced by polygonal areas.

First Instar. Head height .3 mm.; head width .38 mm. Head shiny, light yellow green. Region of ocelli dark brown. Region of future head tubercles light brown. Few transparent hairs scattered over head. Body 2 mm. long. General color light yellow almost cream. First abdominal segment very dark maroon dorsally. Body covered with long microscopically serrate hairs. The basal two thirds of the dorsal prothoracic hairs are black, the distal ends transparent and colorless. The remaining dorsal hairs of the body are black on the basal third. All dorsal hairs forwardly recurved. Hairs below the subventral fold backwardly recurved. The arrangement of the hairs on the prothoracic segment is shown in Plate VI Figure 3. Along the anterior edge of the cervical shield are four pairs of long forwardly recurved hairs arranged in a transverse line. Slightly posterior to the most lateral one and approximately dorsal to the spiracle is a short hair. There are two prespiracular hairs and the usual two hairs in the subventral position. The arrangement of the hairs on the fourth abdominal segment is shown in Plate VI Figure 4. Hairs i and iii lie at the anterior edge of the segment in a position more anterior than the spiracle. iv is posterior to the spiracle and v ventral to it. ii, iv, vi, vii, and viii lie in a line along the posterior edge of the segment. The hairs do not arise from conspicuous scleritized areas as in the preceding species. Legs same color as body. Spiracles with brown rims. Crochets uniordinal forming an elipse.

Second Instar. Head height .5 mm.; head width .575 mm. Head smooth, clear chalcedony yellow. The spines and the region of the ocelli are dark brown to black. Plate V Figure 2 shows the head spines and the distribution of the hairs. Body 2.5 to 3 mm. long. Chalcedony yellow. Covered with large branched spines. Green from gut visible. Legs and spiracles same as in previous instar.

Third Instar. Head height .7 mm.; head width .9 mm. Similar to second instar. Head spines longer and more conspicuous (Plate VI Figure 11). Body 5 mm. long. Shiny empire green. Spines conspicuously black. Dsitribution of spines same as in previous instars.

Fourth Instar. Head height 1 mm.; head width 1.2 mm. Head similar to previous instars. Lateral and ventral areas slightly suffused with green. Body 6 mm. long. Same color as before. Spines larger. Large branched substigmatal spines occur on all but the prothoracic segment. Here there is a prominent prespiracular spine (Plate VI Figure 5). Suprastigmatal branched spines occur on all segments. Those on the prothoracic and mesothoracic segments are more postspiracular in position. Branched para-dorsal spines occur on all but the first thoracic segment. The paradorsal spine on the second thoracic segment is much reduced (Plate VI Figure 8). Mid-dorsal spines are found on all the abdominal segments. The surface of the body is finely rugose. The rugosities are deep maroon in color against a yellowish surface background. The green color of the body is due in great part to the color in the viscera. Legs same color as body. Spiracles with black rims.

Eggs laid July 8 hatched July 12, four days later. The first instar required two days with moulting taking place July 14. The second instar required three days with moults occurring July 17. The third instar required five days moulting occurring July 22. The female oviposited on species of *Tradescantia* and on *Lippia.*

The former was probably chosen by the female in error due to its proximity to the food plant. Larvæ would not feed on it.

Eumæus atala Poey

The larva and chrysalis of this species have been described in part by Scudder (1875). The following account deals primarily with the arrangement of setæ and body colors, aspects not previously considered.

Last Instar. Head height 2 mm.; head width 2.5 mm. Head yellowish. Few minute scattered hairs. The distribution of these is shown in Plate V Figure 4. On the head the primary and secondary setæ are indistinguishable. They are of little diagnostic value since they vary so greatly in number and position. Plate VI Figures 9 and 10 illustrate the marked variation in the distribution of these head setæ in different specimens of this species. The apex of the head is deeply indented. Surface smooth. Body 20 mm. long. General color brilliant crimson. First and last segments yellowish. Legs, prolegs, and para-dorsal spines yellow. Spiracles light brown, spherical. Para-dorsal row of fleshy tubercles on every segment. Each bears three to five stiff black spines. The para-dorsal tubercles on the first and last body segments are not distinct. Body covered with much short brown secondary hair. A substigmatal row of fleshy protuberances crimson in color. Prothoracic segment enlarged. Crochets triordinal, numbering approximately thirty-three. Arranged in one interrupted band with a spatulate fleshy lobe arising near the interruption.

Chrysalis. Length 15 mm. General color sienna. Scattered brownish spots.

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EXPLANATION OF PLATE V

Fig. 1. Head of first instar larva of *Precis zonalis* Felder & Felder. Approximately x 58.

Fig. 2. Head of second instar larva of *Anartia lytrea chrysopelea* Hbn. Approximately x 33.

Fig. 3. Head of first instar larva of *Anartia jatrophe jamaicensis* Moesch. Approximately x 65.

Fig. 4. Head of last instar larva of *Eumæus atala* Poey. Approximately x 14.

Fig. 5. Head of third instar larva of *P. zonalis* Felder & Felder. Approximately x 40.

Fig. 6. Head of second instar larva of *A. jatrophe jamaicensis.* Approximately x 48.

EXPLANATION OF PLATE VI

Fig. 1. Prothoracic segment of first instar larva of *Anartia jatrophe jamaicensis* Moesch. showing the arrangement of the setæ dorsal to the subventral fold. A, anterior; P, posterior. Approximately x 100.

Fig. 2. Fourth abdominal segment of first instar larva of *A. jatrophe jamaicensis* Moesch, showing the arrangement of setæ I to V. A, anterior; P, posterior. Approximately x 100.

Fig. 3. Prothoracic segment of first instar larva of *Anartia lytrea chyrsopelea* Hbn. showing the arrangement of the setæ dorsal to the subventral fold. A, anterior; P, posterior. Approximately x 66.

Fig. 4. Fourth abdominal segment of first instar larva of *A. lytrea chrysopelea* Hbn. showing the arrangement of setæ I to V. A, anterior; P, posterior; S, subventral fold. Approximately x 90.

Fig. 5. Prespiracular spine from the prothoracic segment of fourth instar larva of *A. lytrea chrysopelea* Hbn. Approximately x 66.

Fig. 6. Para-dorsal spine from the first abdominal segment of second instar larva of *A. jatrophe jamaicensis* Moesch. Approximately x 66.

Fig. 7. Para-dorsal spine from the first abdominal segment of fourth instar larva of *Precis zonalis* Felder & Felder. Approximately x 40.

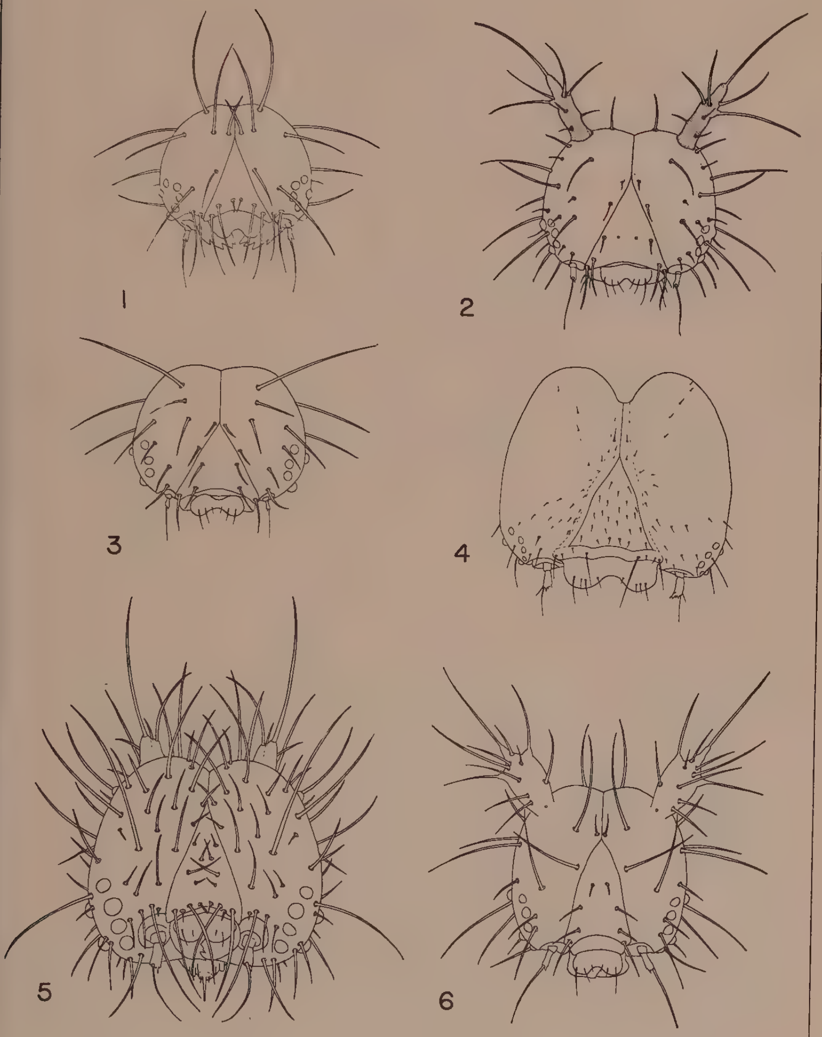
Fig. 8. Para-dorsal spine from the second thoracic segment of fourth instar larva of *A. lytrea chrysopelea* Hbn. Approximately x 70.

Fig. 9. Clypeus of last instar larva of *Eumæus atala* Poey showing the arrangement of setæ. Approximately x 30.

Fig. 10. Same.

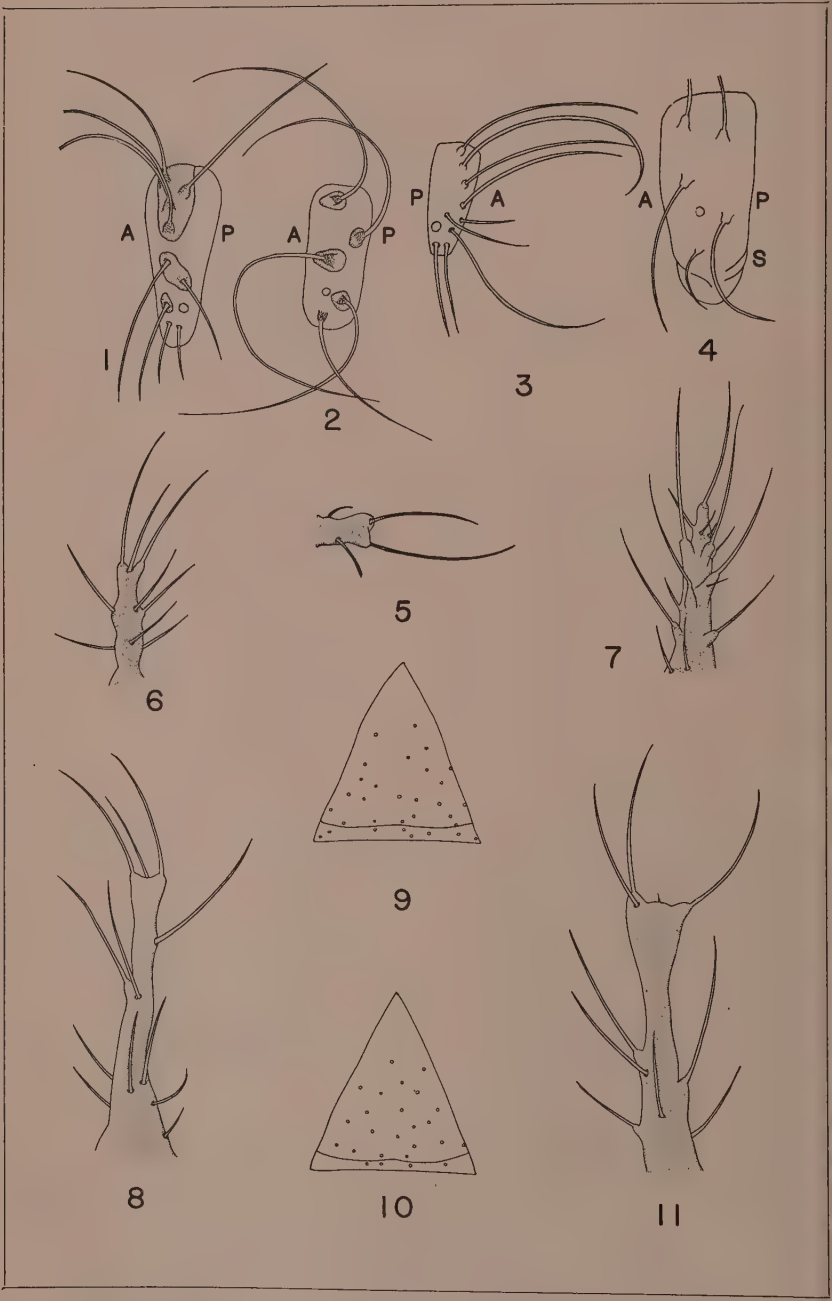
Fig. 11. Spine from head of third instar larva of A. *lytrea chrysopelea* Hbn. Approximately x 90.

PSYCHE, 1941 VOL. 48, PLATE V



Dethier — Cuban Nymphalidæ and Lycaenidæ

PSYCHE, 1941 VOL. 48, PLATE VI



Dethier — Cuban Nymphalidæ and Lycaenidæ

THE TERMINAL ABDOMINAL STRUCTURES OF MALE DIPTERA

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The interpretation of the structures here described, was worked out a number of years ago, in preparing the chapter on the morphology of the Diptera for the forthcoming volumes of the Diptera of Connecticut; but the publication of this work has been indefinitely postponed due to lack of funds for its publication. Since the facts brought out in this study are rather "revolutionary" and indicate that the current interpretations of the terminal structures of male Diptera should be drastically revised, it has seemed advisable to present these facts at this time instead of waiting any longer to publish them.

Many male Diptera are able to twist their terminal abdominal segments about at least temporarily, in adaptation to the different positions assumed by the males during copulation, and a permanent displacement of the parts may occur as early as the pupal stage in the Cyclorrhapha (*Calliphora*), or just after emerging from the pupal stage, as in the Culicidæ, certain Tipulidæ, etc.

Even such primitive Diptera as the Tanyderid *Protoplasa fitchii* may exhibit an inversion of the ninth abdominal segment, as is indicated by all of the males of this species which I have examined (suggesting that the rotation may be permanent, instead of a temporary adaptation during copulation), and a permanent inversion of the ninth segment (which is rotated about the long axis through 180 degrees) occurs in male Culicidæ, certain Tipulidæ, etc., among the Nematocera. Among the Brachycera, an inversion, or torsion, may occur in certain Asilidæ and Dolichopodidæ, as well as in the Bombyliidæ and Certidæ, while a similar tendency toward a torsion of the parts is exhibited by the

Phoridæ Lonchopteridæ, etc., which occupy a border-line position between the Brachycera and the Cyclorrhapha (being placed among the Brachycera by some dipterists, while others place them in the Cyclorrhapha). A permanent torsion of the parts apparently occurs in all true Cyclorrhapha, as is indicated by a displacement of the external sclerites, spiracles, etc., and by the looping up of the ejaculatory duct, etc., over the top of the hindgut (from left to right) in all of the Cyclorrhapha I have examined (see Figs. 17 and 19 for illustrations of such a looping over of the parts in question).

In such Nematocera as the male Culicidæ, an inversion of of the ninth segment (together with the proctiger, or anus-bearing segmental complex) occurs by rotating the parts (through 180 degrees) from left to right around the long axis of the body of the insect; and the designation "rotation" should be restricted to such a transverse revolving of the parts around the long axis of the insect. The resulting inversion may be termed a rotated inversion or "transinversion" to distinguish it from the next type to be considered. After an inversion of this type, the anus, genitalia, etc., still project posteriorly along the long axis of the body.

In many of the higher Diptera, on the other hand, an inversion of the ninth segment (with the proctiger) may occur by twisting it forward and around in a more vertical plane. The resulting inversion may be termed a torque inversion, or "retroinversion", to distinguish it from the type of inversion mentioned above. After an inversion of this type, the anus, etc., is usually directed forward (instead of posteriorly), as is the case in the Syrphid *Heliophilus*, shown in Fig. 6, and in the Pyrgotid (Ortalid) *Pyrgota*, shown in Fig. 3. This type of torsion usually involves the displacement of the eighth sternite, which may be accompanied by the seventh and even the sixth, abdominal sternite as it is twisted upward. The way in which the displacement and modification of the parts has been brought about in the higher Diptera may be illustrated by a series of male Diptera shown in Figures 1 to 9, inclusive.

The Bibionid *Dilophus* shown in Fig. 1 may be taken as the starting point for the series, since the condition exhibited by it is fairly typical of the Nematocera in general, in which the ninth segment with the proctiger, etc., extends straight back in the long axis of the body (see also the primitive Nematoceran *Trichocera,* shown in Fig. 14). In *Dilophus* (Fig. 1) the eighth sternite 8s is very large, and shows no sign of displacement.

In the next stage represented by the Rhagionid (Leptid) *Rhagio,* shown in Fig. 2, the ninth segment is tilted upward and the conjunctivae or intersegmental membranes are very extensive, giving free play to the temporary twisting of the parts in mating. The eighth tergite 8t is reduced, but the eighth sternite 8s remains large, and the parts of the seventh segment are not effected by the process.

A slightly higher stage of specialization is illustrated by the Stratiomyid *Ptecticus,* shown in Fig. 4. In this fly the ninth segment is very large and the conjunctiva are very extensive to permit a twisting of the parts in copulation. The tergites of both the eighth and the seventh abdominal segments are reduced to narrow transverse strips, and the eighth sternite 8s shows signs of having been slightly displaced upward, at least temporarily, during the mating process (this specimen was captured in copula).

A still higher stage of specialization is illustated by the Syrphid *Heliophilus* shown in Fig. 6. The ninth abdominal segment remains permanently twisted forward in the torsion process, and the huge eighth sternite 8s, although still ventrally located, becomes slightly lateroverted, or displaced upward into the insect's left side. The eighth tergite has become atrophied, or is represented by the narrow transverse sclerite lying just behind the seventh tergite, 7t, and anterodorsad of the eighth sternite. The seventh tergite, 7t, is reduced, as is also the case with the sixth and fifth abdominal tergites, 6t, and 5t; and their sternites exhibit indications of slight lateroversion.

Turning next to the Syrphid *Chrysotaxoides,* shown in Fig. 8, we note that the ninth abdominal segment, 9t, is twisted still further around (ventrally) and the huge eighth sternite, 8s, becomes drawn up into the dorsal region, and is almost inverted. The seventh sternite, 7s, follows it to some extent, and is lateroverted into the insect's left side, but the seventh tergite, 7t, is not greatly affected by the process, and the left spiracle of the seventh segment remains but slightly displaced upward. In the Syrphid *Syrphus rectus* shown in Fig. 17, the ninth segment faces more nearly backward as the result of the continued twisting process, and the sixth and seventh sternites, 6s and 7s, follow the eighth sternite, 8s, as it becomes drawn upward. The ejaculatory dust, ed, shows through the thin integument of this Syrphid, and clearly indicates that there has been a clockwise torsion (viewing the insect from behind) of the parts, since the duct loops up over the top of the hindgut, from left to right. If there is any doubt that the sclerite 8s, interpreted as a sternite in these insects, is actually a sternite, rather than a tergite, it is only necessary to compare the parts with those of the Pyrgotid (Ortalid) *Pyrgota undata*, shown in Fig. 3, in which the huge eighth sternite, 8s, is only slightly lateroverted into the insect's left side, and preserves its typical relation to the seventh and sixth sternites, labelled 7s and 6s in Fig. 3; and if the sclerite labelled 8s were a tergite, instead of a sternite, the torsion would have to take place in a counter-clockwise manner, which it does not do in any of the insects whose internal structures have been examined.

Turning next to the Coelopid *Coelopa frigida* shown in Fig. 5, we note that the ninth tergite, 9t, has now completed the torsion process, and the anus faces posteriorly again, from this stage onward. The genitalia project downward, however, (instead of posteriorly as in the Nematocrea), and the aedeagus, ae, now projects anteriorly (instead of posteriorly) as in most Cyclorrhapha. This completion of the torsion process is spoken of as a "circumversion" or a reversion. The eighth sternite, 8s, has now become almost inverted and the asymmetrical seventh sternite, 7s, follows it upward into the insect's left side. The spiracle of the right side of the seventh segment has apparently become drawn down and around into the insect's left side, and the small narrow sclerite just below it appears to be the remains of a portion of the seventh tergite. The asymmetrical sixth sternite, 6s, is lateroverted and the right spiracle of the sixth segment is drawn down and around into the insect's left side indicating the extent of the torsion process in this region. The fifth segment is not affected by the process, in the Muscoids in general.

A further advance in the direction of the Muscoid flies is illustrated by the Helomyzid *Neoleria crassipes* shown in Fig. 7, in which the relative proportions of the segments are essentially those characteristic of the typical Muscoid flies next to be considered. The fifth segment is practically unmodified, the sixth tergite, 6t, retains its normal position, but its asymmetrically developed sternite, 6s, is lateroverted and becomes attached by one corner to the lateroverted seventh sternite, 7s, which, in turn, is attached by one corner to the inverted eighth sternite, 8s. The left spiracle of the seventh abdominal segment is displaced dorsad, but is not enclosed in the sclerites behind it.

A higher stage of specialization is illustrated by the Muscid *Hylemya antiqua* shown in Fig. 20, in which the parts bear essentially the same relations to each other as they do in Fig. 7, save that the seventh sternite, 7s, has now become adherent to the eighth sternite, 8s, from which it is demarked by an incomplete suture; and the left spiracle of the seventh segment is now borne in the anterior region of the composite sclerite made up of the lateroverted seventh sternite and the inverted eighth sternite (with which the reduced seventh tergite may also have united, although the fate of the seventh tergite cannot be definitely determined from the available material).

We may speak of the composite sclerite made up of the uniting seventh and eighth sternites (7s and 8s of Fig. 20) as a synsternite, to denote the fact that it is composed of the sternites of more than one segment, although it is usually spoken of as one "segment," called the first genital "segment," while the ninth segment is then called the second genital segment. The so-called second genital segment, (or ninth abdominal segment) of the Muscoid flies is called the andrium in lower insects, while its sternite is called the hypandrium and its tergite is called the epandrium; and these terms might also be applied to the parts in Muscoid flies, in which the term protandrium might then be substituted for the designation "first genital segment," which is not a single segment but is a composite synsternite.

The slender curved sixth sternite 6s of Fig. 20 supports a genital pouch, or cubiculum, in which the anteriorly directed aedeagus, ae, is received in repose, and this type of structure is typical of many Muscoidea. The fifth sternite labelled 5s in Fig. 20, has become cleft posteriorly to form two copulatory lobes, labelled 1, which function in the mating process, and also project backward below the aedeagus to protect it when it is received in the genital pouch.

The Metopiid fly *Phormia regina* shown in Fig. 21 is typical of the Muscoidea in general, and may serve as the basis for comparing the parts in the other members of this superfamily. Its structures are essentially like those of the fly shown in Fig. 20, but the union of the seventh sternite, 7s, with the eighth sternite, 8s, is more complete, and the seventh sternite is apparently reduced to the small indistinct area labelled 7s in Fig. 21. The left spiracle of the seventh abdominal segment is borne near the anterior border of the synsternite (composite seventh and eighth sternites) in Fig. 21, but in the Muscid fly *Parallelomma,* in which the synsternite (or composite seventh and eighth sternites) becomes greatly enlarged along the long axis of the body, the spiracle in question is situated far back in the enlarged synsternite, which may indicate that the seventh sternite, which contributes to the formation of the synsternite, is of considerable extent. On the other hand, in another Muscid fly *Musca domestica,* in which the synsternite is reduced to a narrow transverse sclerite, the left spiracle of the seventh segment remains far down toward the anterior margin of the synsternite, indicating that the seventh sternite forms a relatively unimportant portion of the reduced synsternite.

In *Musca domestica* a further specialization is indicated by the fact that the sixth abdominal sternite (which exhibits a tendency to attach itself to the synsternite labelled 7s and 8s in Fig. 21) migrates from its position below the sixth tergite, and becomes so closely associated with the ventral region of the narrow transverse synsternite that it appears to be the sternite of a segment whose tergite is represented by the narrow transverse synsternite; and it is small wonder that these structures have been misinterpreted in *Musca domestica,* although a comparison of the parts with those of the Muscoid fly shown in Fig. 21 (and tracing the parts on back through the series here described) would readily reveal the true homologies of the parts in the housefly.

The modificational trends exhibited by the series of flies shown in Figs 5, 7, 20 and 21, indicate a rather close relationship between the members of this series, but the modifications exhibited by such a fly as the one shown in Fig. 22, in which the sixth segment remains unaffected by the lateroversion of the seventh sternite 7s (and by the inversion of the eighth sternite 8s) would indicate that *Calobata* is a member of a series quite different from that to which the above mentioned flies belong, and the trends exhibited by these flies should be of considerable value for arranging them according to their natural affinities, although I do not know of any attempt to utilize the sclerites of this region of the body for such a purpose.

In this connection it may be remarked that the modificational trends exhibited by a Dolichopodid fly such as *Argyra* (shown in Fig. 23) seem to foreshadow many of the modifications later occurring in certain Cyclorrapha, just as the antennæ of certain Dolichopodidæ approach those of the typical Cyclorrhapha, and these facts may indicate that the Dolichopodidæ are much nearer to the ancestors of the Cyclorrhapha than is commonly supposed to be the case.

In like manner, the modificational trends exhibited by such Syrphidæ as *Paragus* (shown in Fig. 9) seem to foreshadow the modifications later occurring in certain higher Cyclorrhapha. Thus the lateroverted seventh sternite, 7s, unites with the inverted eighth sternite, 8s, in *Paragus* (Fig. 9) as it does in *Hylemya* (Fig. 20), for example. The sixth sternite, 6s, is asymmetrical and is strongly lateroverted in *Paragus* (Fig. 9), as it is in *Hylemya* (Fig. 20—compare also Fig. 7), and the fifth sternite labelled 5s in Fig. 9 of *Paragus* is deeply emarginated posteriorly, dividing the fifth sternite into widely separated parts which suggest the origin of the condition exhibited by *Hylemya* (Fig. 20), in which a deep posterior cleft divides the fifth sternite into the posteriorly projecting copulatory lobes labelled 1 in Fig. 20. These and many other facts suggest that the Syrphidæ represent the ancestors of certain other Cyclorrhapha as nearly as any known forms; and the Syrphidæ furnish the most useful clues for determining the homologies of the genital structures of the higher Cyclorrhapha, as will be shown later.

Before discussing the homologies of the genital forceps of the lower Diptera a brief statement may be made concerning the nature of the parameres of male Coleoptera and Hymenoptera, which represent the starting point for the derivation of the genital forceps of male Mecoptera, Trichoptera, Diptera, etc. Since the Coleoptera are more "orthopteroid" than the Hymenoptera, the condition exhibited by their genital structures should be more primitive, or ancestral, than is the case with the parts in the Hymenoptera, and the Hymenopterous type was probably derived from the more primitive Coleopterous type of genitalia occurring in such primitive Coleoptera as the Lampyridæ. In males of the common Lampyrid beetle *Lucidota corrusca,* the unsegmented parameres are borne on a broad basal ring corresponding to the narrower basal ring labelled gc in Fig. 11 of the primitive Hymenopteron *Xyela* (so that this type of basal ring is not peculiar to the Hymenoptera alone, as is commonly thought to be the case) in which the basal ring bears a pair of segmented forceps occupying exactly the same position (on each side of the median aedeagus) that the unsegmented parameres do in Lucidota. It is therefore evident that the unsegmented parameres of the more primitive Coleoptera merely become secondarily divided into a basal and distal segment in the Hymenoptera, although Snodgrass, 1941 (Smithsonian Misc. Collections, Vol. 99, No. 14) considers that the parameres of the Hymenoptera are represented by only the distal segments of the forceps. In the following discussion the basal segment of the forceps will be referred to as the basimere or basistyle (b of Figs. 11 to 13) and the distal segment of the forceps will be termed the distimere or dististyle (d of Figs. 11 to 13).

In the Bulletin of the Brooklyn Entomological Society for 1938, Vol. 33, page 3, the writer first called attention to the fact that in male Mecoptera Diptera, etc., the basimeres (b of Figs. 12 and 13) do not represent abdominal coxites, and the distimeres (d of Figs. 12 and 13) do not represent styli, as is commonly supposed to be the case, but these segments of the genital forceps of the Mecoptera, Trichoptera, Diptera, etc., are clearly homologous with the segments labelled b and d of the parameres of such a Hymenopteron as that shown in Fig. 11; and it is difficult to understand how anyone could examine such a series of genital forceps as that shown in Figs. 11, 12 and 13, without immediately realizing this fact, if comparative morphology has any meaning at all. The only baffling difficulty presented by the parts in these insects is the question as to the homology of the basal area bearing the label g in Fig. 13, which may represent either the basal ring gc of Fig. 11, or it may represent the remains of the ninth sternite which unites with the basimeres of the forceps, or it may represent a secondarily demarked area in the basal region of the uniting basimeres of the forceps, and the latter explanation seems as logical as any.

The ninth sternite is separated from the basal segments of the genital forceps in the Trichoceridæ (Fig. 14), as is also the case in such Tipulidæ as *Macrocera*, etc., but in the genus *Tipula* the ninth sternite tends to unite with the basal segments of the genital forceps, and this tendency is carried still further in many other Diptera. In the primitive Dipteron *Protoplasa fitchii* shown in Fig. 15, the ninth sternite 9s apparently becomes greatly reduced before it unites with the basal segments of the forceps, and the condition exhibited by *Protoplasa* suggests that the area labelled g in Fig. 13 may also represent such a reduced ninth sternite which has united with the basal segments of the forceps, although it is also possible that the area labelled g in Fig. 13 is comparable to the region between the bases of the genital forceps in the Trichoceridæ (Fig. 14), and a third possibility is that both the area labelled g in Fig. 13, and that interpreted as the reduced ninth sternite in Fig. 15 (9s), may represent the basal ring of the genital forceps of the Hymenopteron *Xyela* (Fig. 11, gc).

The distal segments of the forceps, labelled d in Fig. 15 of *Protoplasa,* are forked, and if the cleft of the fork were deepened basad, it would eventually divide the distal segment into an inner and outer distimere (or dististyle) like those labelled id and od in Fig. 10 of the Tipulid *Acantholimnophila;* and it is very probable that the outer and inner distimeres or dististyles characteristic of most Tipulidæ arose from such a longitudinal splitting of the distimeres.

The basal segments of the genital forceps of Acantholimnophila bear slender mesal processes called interbases (labelled ib in Fig. 10) ; and the ninth tergite, 9t, of Fig. 10, bears a pair of posterior lobes in this insect, which may correspond to the processes of the ninth tergite labelled st in Fig. 15 of *Protoplasa,* and these in turn may correspond to the long slender processes of the ninth tergite labelled st in Fig. 16 of the Ptychopterid *Bittacomorpha.* It is probable that such processes of the ninth tergite of the lower Nematocera become the articulated processes of the ninth tergite called surstyli, or edita, in such Cyclorrhapha as those shown in Figs. 8, 9, 20 and 21, etc., in which the surstyli are labelled st.

The proctiger, or anus-bearing region behind the ninth tergite, labelled 9t in Figs. 1, 2, 4, 5, 8, etc., is apparently composed of the greatly reduced tenth abdominal segment, with which the similarly reduced, cerci-bearing, eleventh abdominal segment, and the anus-bearing telson, have united. The structures labelled ce in these figures are interpreted as true cerci since they are clearly homologous with the cerci of female Tipulidæ and female Mecoptera, etc., in which the structures in question are borne on a distinct, though greatly reduced, eleventh abdominal segment, as is the case with the cerci of lower insects, in which the cerci are appendages of the eleventh abdominal segment.

In attempting to determine what genital structures of the higher Diptera shown in Figs. 19, 20, 21, etc., correspond to the segments of the genital forceps of the lower Diptera, such as those shown in Figs. 1, 2, 3, etc., it is necessary first to compare them with the parts in the key group Syrphidæ (Fig. 17) which occupies a position intermediate between the higher and the lower Diptera, and furnishes the necessary clues for tracing the modifications met with in the sclerites and other structures of the higher forms.

Starting with the lower Nematocera, in which the segments of the genital forceps b and d are long and slender, as they are in the Nematocera shown in Figs. 14, 15, etc., we note that the segments tend to become shorter and stouter in the genital forceps of the Brachycera shown in Figs. 2 and 4; and in the Stratiomyid *Ptecticus* shown in Fig. 4, the distimeres, labelled d, are broad and flat, like the distimeres labelled d in Fig. 17 of the Syrphid *Syrphus rectus,* while the basimeres labelled b in Fig. 4 of Ptecticus, are reduced and unite with the ninth sternite, as the basimeres, b, do in the Syrphid shown in Fig. 17. It is thus an easy matter to identify the parts of the Syrphid shown in Fig. 17 with those of the lower Diptera, and it is then comparatively easy to identify the structures of the higher Diptera which correspond to the parts in this Syrphid.

In the Muscid fly *Hylemya* shown in Fig. 20, the structures which occupy a position on each side of the base of the aedeagus, ae, comparable to the parts situated on each side of the base of the aedeagus, ae, of the Syrphid shown in Fig. 17, are the so-called anterior and posterior "gonapophyses" (b and d) of Fig. 20, and unless these so-called "gonapophyses" are structers peculiar to the higher Cyclorrhapha, having no relation to the structures of the lower Cyclorrhapha, it is possible that these structures labelled b and d in the higher Cyclorrhapha shown in Figs. 20, 21, etc., may represent the basimeres, b, and the distimeres, d, of the primitive Cyclorrhaphan, *Syrphus*, shown in Fig. 17.[1] In the same way, the appendages, st, of the ninth tergite, 9t, and the lobes, ce, on each side of the anal opening of the higher Cyclorrhapha shown in Figs. 19, 21, etc., may be identified with the surstyli, st, borne on the ninth tergite, 9t, and the cerci, ce, situated on each side of the anal opening, of the Syrphid shown in Fig. 17, and it is thus an easy matter to homologize the structures of the higher Cyclorrhapha by comparing them with the structures of the key group Syrphidæ.

With regard to the minuter details of the genital structures of the higher Diptera, it may be remarked that Lowne, 1895, in the second volume of his monumental work on the blowfly Calliphora, designates the slender structure labelled p in Fig. 21 of *Phormia regina* as the paraphallus, and calls the structure labelled h in Fig. 21 the hypophallus. The genital spine labelled e in Figs. 19 and 21, etc., is usually called the epiphallus, and the basal and distal portions of aedeagus ae, labelled a and ph in Fig. 21 have been called the phallophore and phallus.

Of the internal structures in this region, mention may be made of the phallic apodeme, pa, of Figs. 19 and 21, which operates the parts in the basal region of the aedeagus, and the hypandrial apodeme, ha, of Figs. 19 and 21, which is formed by an internal inflexion of the ninth sternite or hypandrium, 9s, for the attachment of muscles moving these structures. Lowne, 1895, designates the structures labelled pg in Fig. 19, as the paragonia (they have been called seminal vesicles by other writers) and states that the secretions of these structures coagulates in the ejaculatory duct, or in the vagina of the female, to form a type of spermatophore. The seminal fluid is ejaculated through the action of the ejaculator em of Fig. 19, which functions as a syringe to force the fluid out through the aedeagus when the muscles attached to the sclerite in its membranous walls, etc. contract.

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[1] It is preferable to refer to the structures labelled b and d in Figs. 19, 20 and 21, of the higher Cyclorrhapha, simply as the anterior and posterior gonapophyses until their homologies have been definitely determined.

The interpretations given the different structures here discussed are the same as those proposed six years ago in a short paper published in the Bulletin of the Brooklyn Entomological Society for 1936, Vol. 33, No. 4, p. 141. This earlier paper, however, was apparently too brief and the accompanying figures were too few, to carry any conviction for those who have published on the morphology of the Mecoptera, Diptera, etc., since that time, so that no consideration has been given by recent investigators to the views set forth in this previous paper. It is to be hoped, however, that a re-statement of these views, illustrated by a wide series of intermediate forms indicating the steps in the development of the structures of the higher Diptera, will cause other investigators to take these views into consideration, since the conclusions here drawn are based upon an extensive study of a wide range of Dipterous types, and the clear cut evolutionary trends here described must be explained in some other way if the interpretations here suggested are not accepted.

LIST OF ABBREVIATIONS

a	Phallophore
æ	Ædeagus
b	Basimere or basistyle (basal segment of forcipate parameres), also anterior gonapophysis.
ce	Cerci
d	Distimere or dististyle (distal segment of parameres), also posterior gonapophysis.
e	Genital spine or epiphallus
ed	Ejaculatory duct
em	Ejaculator or ejaculatory syringe
g	Area of united basimeres of genital forceps (9th. Sternite?)
gc	Basal ring of forceps (gonocardo)
h	Hypophallus
ha	Hypandrial apodeme
ib	Interbases
id	Inner distimere or dististyle
l	Copulatory lobes of fifth sternite
od	Outer distimere or dististyle
p	Paraphalli
pa	Phallic apodeme, or aedeagal apodeme.
pg	Paragonia
ph	Phallus
ps	Phallosome
r	Rectal papillæ
s	Sternites
st	Surstyli or edita
t	Tergites
ts	Testes

EXPLANATION OF PLATE VII

Fig. 1......Lateral view of terminalia of *Dilophus* (Bibionidæ).
Fig. 2......Lateral view of terminalia of *Rhagio vertebratus* (Rhagionidæ)
Fig. 3......Lateral view of terminalia of *Pyrgota undata* (Pyrgotidæ)
Fig. 4.......Lateral view of terminalia of *Ptecticus* (Stratiomyidæ)
Fig. 5......Lateral view of terminalia of *Cœlopa frigida* (Coelopidæ)
Fig. 6......Lateral view of terminalia of *Heliophilus chaligosa* (Syrphidæ)
Fig. 7......Lateral view of terminalia of *Neoleria crassipes* (Helomyzidæ)
Fig. 8......Lateral view of terminalia of *Sericomyia chrysotaxoides* (Syrphidæ)
Fig. 9......Lateral view of terminalia of *Paragus bicolor* (Syrphidæ)

EXPLANATION OF PLATE VIII

Fig. 10....Dorsal view of genital forceps of *Acantholimnophila maorica* (Tipulidæ)
Fig. 11.... Ventral view of genital forceps of *Xyela* (Tenthredinidæ)
Fig. 12....Ventral view of genital forceps of *Tæniochorista pallata* (Panorpidæ)
Fig. 13....Ventral view of genital forceps of *Rhagio* (Rhagionidæ)
Fig. 14....Lateral view of terminalia of *Trichocera* (Trichoceridæ)
Fig. 15....Lateral view of terminalia of *Protoplasa fitchii* (Tanyderidæ)
Fig. 16....Lateral view of terminalia of *Bittacomorpha* (Ptychopteridæ)
Fig. 17....Ventral view of terminalia of *Syrphus rectus* (Syrphidæ)
Fig. 18....Ventral view of terminalia of *Mesograpta marginata* (Syrphidæ)
Fig. 19....Lateral view of internal genital apparatus of *Phormia regina* (Metopiidæ)
Fig. 20....Lateral view of terminalia of *Hylemya antiqua* (Muscidæ)
Fig. 21....Lateral view of terminalia of *Phormia regina* (Metopiidæ)
Fig. 22....Lateral view of terminalia of *Calobata pallipes* (Colabatidæ)
Fig. 23....Lateral view of terminalia of *Argyra* (Dolichopodidæ)

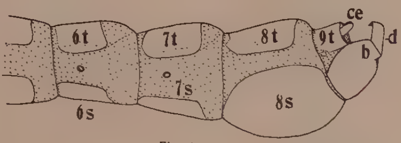
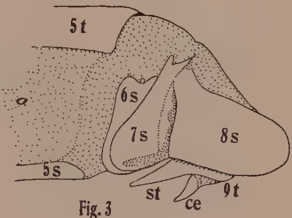


Fig. 1



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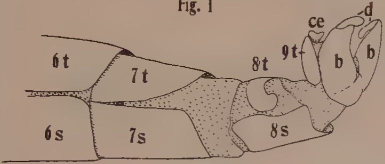

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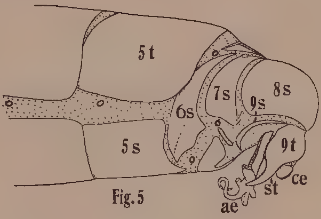

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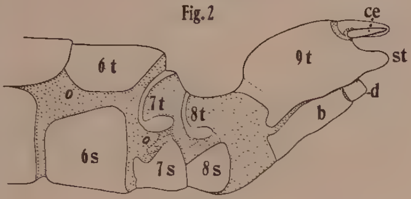

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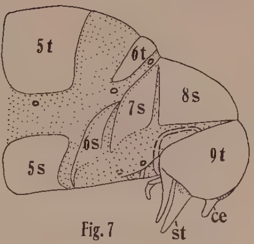

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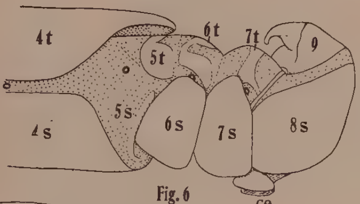

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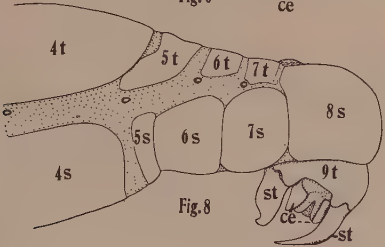

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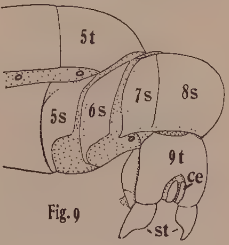


Fig. 9

Crampton — Male Diptera

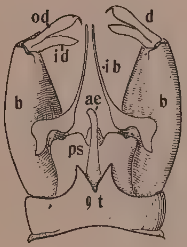


Fig. 10

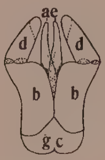
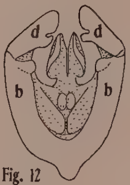


Fig. 11



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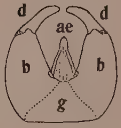


Fig. 13

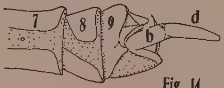


Fig. 14

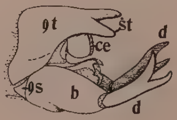
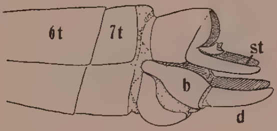


Fig. 15



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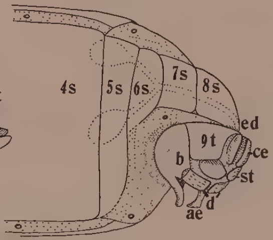
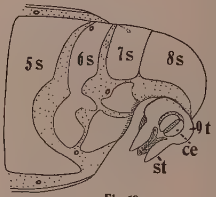


Fig. 17



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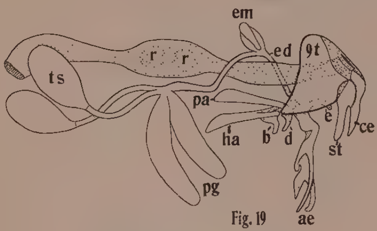

Fig. 19

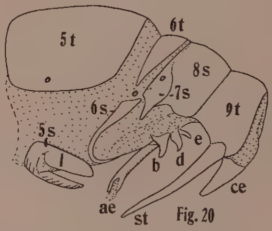

Fig. 20

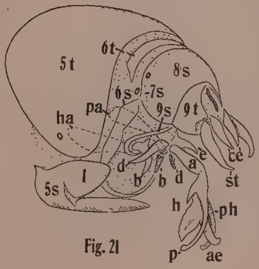

Fig. 21

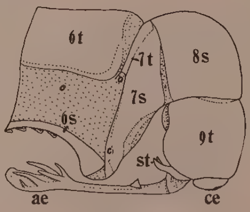

Fig. 22

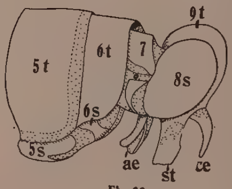

Fig. 23

Crampton — Male Diptera

TWO NEW SPECIES OF ARADIDÆ FROM BALTIC AMBER (HEMIPTERA)

By Robert L. Usinger

University of California, Davis

A considerable collection of Hemiptera from Baltic Amber was received some time ago through the kindness of Prof. F. M. Carpenter. Of this material the aphids were examined by Prof. E. O. Essig, the scale insects by Prof. G. F. Ferris, and a beautifully preserved Tingitid by Dr. C. J. Drake. Two well preserved Aradids are treated in the present paper while the remaining specimens, mostly Fulgorids, Cicadellids, and Mirids, are as yet unstudied.

Only three species of Aradidæ, e.g. *Aradus supiestes*, *assimilis* and *consimilis*, and one Aradid nymph were recorded from Baltic Amber by Germar and Berendt.[1] Although specimens of these species have not been examined, the descriptions and figures clearly indicate that they conform to our present day definition of the nearly cosmopolitan though presumably originally holarctic genus *Aradus*. The present material is of more than usual interest in that the two species are the first representatives of their respective tribes in Baltic Amber. Moreover, the *Calisius* is the first representative of its tribe to be recorded from the fossil record.

Calisius balticus Usinger, new species

Oblong-ovate with sides subparallel, head transverse and antennæ relatively long.

Head one-eighth shorter than broad, 21::24; tylus slightly dilated at about middle, scarcely surpassing level of apices of second antennal segments; antenniferous tubercles short,

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[1] Germar, E. F. and G. C. Berendt. Die im Bernstein befindlichen Hemipteren und Orthopteren der Vorwelt. In Berendt, G. C. Die im Bernstein befindlichen organischen Reste der Vorwelt. Berlin. Band II, Abth. I. pp. 22-23, Tab. II, figs. 11-13, Tab. III, fig. 17. 1856.

reaching about to level of basal third of second antennal segment, divergent and blunt; postocular tubercles distinct but not reaching so far as outer margins of eyes; upper surface feebly elevated with granular areas in front of and behind eyes and with two moderately elevated, anteriorly divergent longitudinal rows of about four large granules each at middle of vertex; eyes small, less than half as wide as interocular space, 5::13. *Antennæ* equal in length to head, the proportion of segments one to four as 3:5:5:8; first and third segments cylindrical, second roundly clavate, fourth fusiform. *Pronotum* just twice as broad across humeri as long on median line, one-seventh shorter than head, 18::21; disk moderately convex with a distinct transverse impression at middle interrupting the four distinct, posteriorly divergent longitudinal carinæ; subparallel median carinæ produced forward slightly beyond base of head; lateral margins nearly straight but for the deep notch at transverse impression, roundly lobed. *Scutellum* a little less than three times as long as pronotum, 51::18, and about half as broad as long; broadest at base where it is somewhat less than two-thirds as broad as long, 28::51, then with the sides concavely sinuate to narrowest point just behind middle where it is distinctly less than half as broad as long, 24::51, widening posteriorly to about half as wide as long and then rounded to broadly rectilinear apex; depressed portion of disk evenly punctate; longitudinal carina well elevated, impunctate; lateral carinæ coarsely granular, almost roundly tuberculate basally; four anteriorly directed projections of basal elevation but feebly developed. *Abdomen* only moderately dilated, about four-fifths as wide as pronotum, 35:43; connexival surface finely granular, the lateral margins of segments each with three feebly developed, rounded tubercles.

Size, male, length 2.5 mm., width (pronotum) .87 mm., (abdomen) 1.07 mm.

Holotype: No. 4634 (male), Museum of Comparative Zoology, Harvard University; in Haren collection of Baltic amber insects.

Closest to the European *ghilianii* (Costa) but smaller than that species with broader head, less prominent tubercles on head, pronotum, and base of scutellum, and entirely distinct antennæ. The antennæ of a female specimen of *ghilianii*, determined by Montandon and kindly loaned for comparison by Mr. W. E. China of the British Museum (Natural History), are much shorter than the head, 19::26, with the proportional length of segments one to four as 4:4:4:7.

The species of *Calisius*, due to their obscure habits and small size, have escaped the notice of most general collectors and hence are very imperfectly known. Most of the twenty-one species were described by Bergroth [2, 3] or by Horvath[4] in his excellent monograph of the old world species. Costa, Stal, Champion, Kirkaldy, and Schouteden have likewise added species and three as yet undescribed species are before me from islands of the south Pacific.

Occasional records from widespread localities throughout the world suggest that the tribe Calisiini is very widespread and may even prove to be tropicopolitan, though no species have yet been recorded from the great Oriental Realm. With New Guinea (4 species) as a possible center, somewhat less than half of the species known to me radiate southward to Australia and Tasmania, eastward to Fiji and the islands of central and southeastern Polynesia, and northward to Micronesia. All of these species, as well as the two European species, *ghilianii* and *salicis*, are similar in body form and lack the prominent black granules at the apex of the scutellum and on the sides of the scutellum near the middle which are characteristic of the American species.

The discovery of an Oligocene species which is clearly congeneric though falling in a separate group, as used above, with greatly reduced connexival and other granules, a very broad head, and uniformly dull and immaculate coloration indicates great age and relative stability for the group. A warmer climate and probably different limits of tolerance doubtless permitted *Calisius balticus* to survive so far north

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[2] Bergroth, E. Notes on American Hemiptera. II. Canadian Ent., 45:1-8, 1913.

[3] Bergroth, E. A New Species of Calisius. Canadian Ent., 45:9, 1913.

[4] Horvath, G. Species mundi antiqui generis Calisius. Ann. Mus. Nat. Hungarici, 11:623-634, 10 figs., 1913.

for neither *ghilianii* nor *salicis* extends today beyond middle Europe.

Mezira succinica Usinger, new species

Figure 1

A relatively large species with broad depressed head, flattened and anteriorly dilated paraclypeal lobes reaching level of apex of first antennal segment, strongly produced postocular tubercles distinctly surpassing outer margins of eyes, moderately anteriorly produced and broadly rounded anterolateral pronotal angles, and strongly convex male genital capsule which exceeds lobes of basal genital segment. Surface in great part coarsely granular.

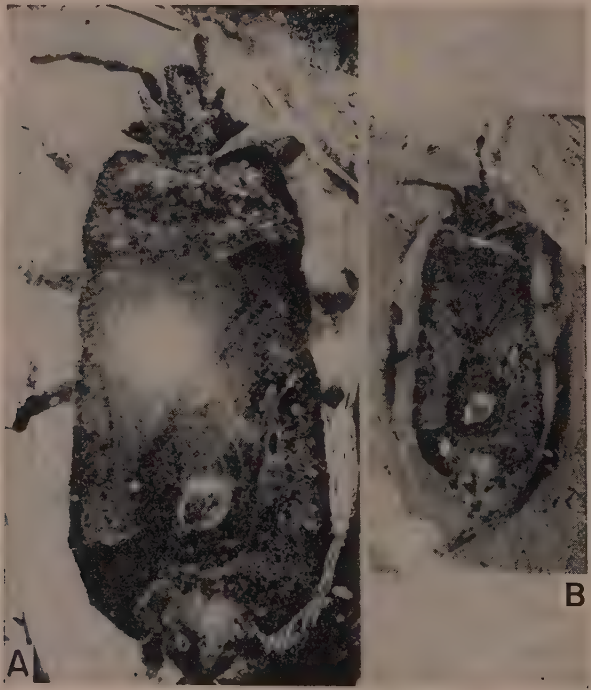

Figure 1. *Mezira succinica* n.sp. Photograph of holotype. A, x 8; B, x 4.

Male. *Head* broadest across postocular tubercles, transverse, the ratio of width to length as 6::5; anterior portion of head beyond insertion of antennæ almost as long as basal portion of head, 21::25, the tylus reaching slightly beyond its middle with the lateral lobes contiguous beyond it, subflattened, and dilated apically; antenniferous tubercles, measured from base of cleft in which the antennæ are inserted, two-thirds as long as first antennal segment and, though strongly produced, rather blunt at apices; postocular tubercles strongly produced, exceeding outer margins of eyes by a distance nearly equal to exposed width of an eye, 4½::6; disk apparently concave, though elevated along tylus and middle of base, because of elevated sides including eyes and postocular and antenniferous tubercles and especially because of strongly elevated lateral plates which cover inner portions of each eye. *Antennæ* stout, the greatest thickness of first segment about equal to that of apex of front femur; short, the total length scarcely more than one-sixth longer than greatest width of head, 73::60; proportion of segments one to four as 19:18:17:19; first segment reaching level of apex of head. Rostrum obscured but not exceeding base of head. *Pronotum* transverse, being a little over twice as broad as long, 104::49; subequal to head on median line; posterior margin distinctly concave in front of scutellum; anterior margin likewise distinctly concave so that the pronotum is actually two-sevenths longer laterally than at middle; sides sinuately narrowed and distinctly elevated in front of broadest posterior fourth; antero-lateral angles extending to level of basal fifth of head, broadly, evenly rounded; disk depressed on anterior lobe between four elevated callosities and within elevated lateral margins. *Scutellum* about as long as pronotum on median line, its disk scarcely elevated basally, surrounded by abruptly elevated carinæ broken only narrowly at apex and with a distinct longitudinal carina at middle which does not reach to apex; shape subtriangular, the base slightly arcuate and sides evenly narrowed to apical fourth and then briefly subparallel to rounded apex. *Hemelytra* reaching nearly to base of genital capsule, strongly narrowed posteriorly when at rest, the transverse width at level of apices of coria only half the width of abdomen at this point; basal third of corium only moderately dilated and feebly arcuate, the distance across dilated bases of coria only slightly greater than greatest width of pronotum, 109::104, outer margin of corium beyond this concave to subangular apex; apical margin feebly, evenly arcuate. Connexivum unlike the rest of dorsal surface, apparently coarsely punctate. *Abdomen* gradually widening to the briefly flaring posterior lateral margins of fourth visible segment at which point it is almost one-fourth wider than greatest width of pronotum, 125::104, the margins of fifth segment concave but posteriorly convergent and margins of sixth gradually rounded. Lobes of sixth abdominal segment reaching apical eighth of greatly enlarged and obscured terminal segment. Under surface almost entirely clouded by a while film but with the abdominal venter evidently evenly and relatively finely granulate-punctate. Legs short, the femora strongly incrassate at middle. Color of entire body apparently rather uniform dark brown.

Size, length 7.45 mm., width (pronotum) 2.6 mm. (abdomen) 3.2 mm.

Holotype: No. 4635 (male), Museum of Comparative Zoology, Harvard University; in Haren collection of Baltic amber insects.

Closely allied to the widespread European *Mezira tremulæ* (Germar) which occurs along the shores of the Baltic today.[5] However, the antennæ are shorter and stouter, the paraclypeal lobes are broader and more dilated anteriorly, the antero-lateral pronotal angles are more produced anteriorly and are broadly rounded and the size is smaller than in *tremulæ*.

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[5] Schumacher, F. *Mezira tremulæ* (Germar), ein Naturdenkmal aus dem Urwalde von Bialowies in Polen. Deutsch. Ent. Zeit., 1919: 285-288, 3 figs., 1 map. 1919.

THREE NEW SPECIES OF MYRMELEONIDÆ

By Nathan Banks

Dr. J. Bequaert on his recent trip to Arizona collected, with Mr. E. R. Tinkham, specimens of a new Myrmeleonid of the genus Eremoleon. It was found in a mine-shaft, and doubtless occurs in caves. The specimens are pale, the markings, although slight, are distinct, so that they are not teneral. This makes four species of this genus in the United States, others occur in Mexico.

Mr. John L. Sperry has recently sent me a small Myrmeleonid taken by himself and wife in California. It is a new species of Clathroneuria distinguished from all others by the very short tibial spurs.

I have added the description of a new form from the West Indies, a species of Puren whose known species occur in the western United States, Baja California, and Chile.

Eremoleon pallens, sp. nov.

Head and thorax pale yellowish, a faint brown mark above antennæ, sometimes faint brown spots on vertex; tip of antennæ black, before it is a stretch of pale, and the basal half mostly pale, but more or less marked, mostly above, with dark; palpi scarcely dark at tips; pronotum has the front part more or less pale brown, with a narrow median pale stripe, behind with two submedian brown stripes, sometimes scarcely indicated, and a short lateral pale brown stripe; thorax above with pale brown areas, more or less separated; pleura pale; abdomen pale, with dark bands above at near tip of several segments, much as in *E. nigribasis*, but the dark on the segments tends to spread forward in middle, so sometimes the segment is largely dark above. Legs pale, tips of femora and tip and subbasal spot on tibiæ dark.

Fore wings without the basal black spot of *E. nigribasis* and without the clouds on radials of *E. macer*, few of the cross-veins brown-bordered; the subcosta, radius and cubitus are interrupted with dark spots or streaks; there are four distinct almost black marks, all small; one at the connection of anal and cubital fork, one at the rhegma, one at and above the union of the radius and subcosta, and one on the last radial cross-vein beyond the stigma, all prominent; usually a few cross-veins obliquely beyond the rhegma less distinctly marked; many of the cross-veins are dark only at ends, the few cross-veins in apical area are pale, behind cubitus and toward tip are more dark cross-veins. In hind wing the three apical dark marks are present, but none near end of anal.

The pronotum is rather shorter than in *E. nigribasis,* the hair above is black, no long white ones on lower sides.

The fore wings are shaped more like *E. macer,* more broadened beyond the anal vein than in *E. nigribasis;* five to seven cross-veins before the radial sector, six radials before the stigma, about seven branches to radial sector, two or three cross-veins between cubital fork and first anal vein, and about five before cubital fork, none crossed.

The legs are slender as in other species, the basal tarsal joint fully as long, the spurs on front legs are equal to three joints, those of hind pair a little more than two joints.

Length of fore wing 22 to 25 mm., width 7 to 8 mm.

From Picacho Peak, Arizona, 23 July (Bequaert, Tinkham, and Flock), in a mine shaft. Type M.C.Z. no. 25519; paratypes, M.C.Z., Univ. Arizona, and with E. R. Tinkham.

Puren imbellis sp. nov.

Head and thorax yellowish, face with a large dark interantennal mark, truncate below antennæ, and above extending nearly to the vertex, but leaving a median pale yellowish spot; first vertex row of four almost connected black lines, behind is a row of brown spots, the median pair extending backward; palpi pale, last joint of labial palpi scarcely dark; antennæ pale on basal half, the joints faintly ringed with brown, beyond becoming darker where the tip is nearly black.

Pronotum pale brownish, with a median white line, and a lateral dark brown stripe near edge; thorax above pale brownish in middle, dark on sides and lobes; pleura pale yellowish; abdomen brown, with a pale median line or spots, that on second segment is a line, elongately enlarged at middle, and slightly enlarged at tip; third segment has a broad pale spot at base, partly divided at base and followed by a line which is widened at tip; fourth segment with a large pale spot at base, tapering toward tip; beyond mostly brown.

Legs pale, tips of femora dark, front and mid tibiæ largely dark, hind tibia dark at tip only, tarsi mostly dark at base and tip. Fore wings with the subcosta much interrupted with brown, radius with longer brown streaks, cubitus with more separated streaks; cross-veins often dark at ends; an oblique brown line up from near end of anal vein, and another obliquely outward from the rhegma; last radial cross-vein plainly bordered with brown, and some others faintly marked behind it, in hind wing last radial cross-vein bordered with dark.

Pronotum nearly as broad behind as long in middle, sides parallel, only short black hair above. Legs not as stout as in *P. inscriptus*, the femora not swollen; front and mid tibiæ with both black and white spines, hind tibiæ with black spines; spurs of front legs equal to three joints, of hind legs equal to two tarsal joints. In the fore wings the costal area is swollen, and the double series of cells reaches to the origin of radial sector; seven cross-veins before radial sector, ten radials before stigma, ten or eleven branches to radial sector, four cross-veins between cubital fork and first anal vein, no cubito-anal cells crossed; venation not especially dense.

In hind wing the tip is acute, the hind margin toward base almost concave, twelve radials before stigma, anal vein ends some distance before cubital fork, and with but four branches to margin.

Length of fore wing 23 mm., width 5 mm., length of hind wing 23.5 mm., width 4 mm.

From Port au Prince, Haiti, 20 November, R. C. Smith collector. Type M.C.Z. no. 25520.

Clathroneuria arioles sp. nov.

Face with a large black interantennal mark, reaching well below the antennæ and up nearly to the first vertex row, between this and the vertex mark is a pale transverse line from eye to eye; vertex largely black with two small pale spots near middle of front and two on each side toward eyes; antennæ dull black, tip rather paler; palpi black, last joint moderately swollen; pronotum with a very broad black median stripe, in the front part of which is a median pale line, and on each side of posterior two-thirds is another pale stripe; there is a short submarginal dark stripe on posterior part each side. Meso- and metanotum mostly black, more or less spotted with pale, mostly near middle; pleura dark, with a few pale spots below wings. Abdomen dull black the first, second, and basal half of third segments with a pale stripe each side above. Legs pale, the femora and tibiæ with some black spots or bands, apex of tibia black, tarsi with the whole of the fourth joint, and the tip of the others black.

Wings with the venation largely black, the subcosta much interrupted with snow-white, the radius less interrupted with pale, toward stigma the medius is white for a long distance, cubitus interrupted with white, and also the radial sector; many cross-veins partly or wholly white. Along the cubitus and at intervals beyond it is bordered with black, and a longer black streak obliquely up from the rhegma; at base of stigma and back on radius it is black.

In hind wings venation mostly black, but subcosta and radius interrupted with pale.

Pronotum much longer than broad, narrowed in front, the erect bristles are black, and short more appressed hair is white. Wings slender; in fore wing three cross-veins before radial sector, latter with six branches, some of the costals forked before stigma, a few cross-veins in apical field, eight or nine cubito-anal cross-veins before cubital fork, none connected; first anal vein connected to cubital fork three times; third anal with small apical fork; most of the cells in middle of wing are plainly longer than broad.

In hind wings two cross-veins before radial sector, latter with six branches, first anal connected once to cubital fork and with eight or nine branches to the margin.

The legs are moderately slender, more so than in the other small species of the genus, especially long is the tibia; most of the bristles are black; the spurs, unlike all the allied species, are short, hardly two-thirds as long as the basitarsus.

Length of body 20 mm., length of fore wing 16 mm., width 4 mm. One from Riverside, Calif., 25 September 1940, from Grace H. and John L. Sperry, to whom I am much indebted for many fine Neuroptera. Readily separated from others by the abbreviated tibial spurs. Type M.C.Z. no. 25568.

CONCERNING THE ANTIQUITY OF SOCIAL INSECTS

By Roland W. Brown

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In the March 1941 number of this journal J. C. Bequaert and F. M. Carpenter[1] published a six-page discussion of the antiquity of social insects. Two thirds of this space was given to a formulation of criticisms purporting to cast doubt on my identification of an object from Upper Cretaceous strata in southwestern Utah as the comb of a wasp nest called *Celliforma favosites.*[2] As most of these criticisms do not appear to be well founded a rejoinder is necessary to clarify the issue.

A small matter of terminology first needs attention. In footnote 2 Bequaert and Carpenter object to my use of the term *mold* for the fossil and say that they consider *cast* more appropriate. The popular conception of a *cast* is that of a *casting,* which is anything that has been poured into and, after hardening, has been removed from a *mold. Casting* in this sense is a general term. Paleontologists, sculptors, and others, however, use the term *cast* in a specific sense, namely, as a duplicate or positive of the original object; and *mold* as the reverse or negative of that object. Consequently, as the fossil I have described is merely the filling of the cells, it is not a duplicate of the original paper nest itself and is therefore not a *cast* but a *mold.*

It should be noted particularly, before considering their arguments in detail, that Bequaert and Carpenter do not deny that the object in question is a fossil, although I myself had qualms on this point and withheld publication for four years, because I sought evidence from mineralogy to account for the origin of the specimen by inorganic means alone. Receiving no encouragement in this direction from mineralogists I conceived and published a solution based on the hypothesis of an organic origin. That this hypothesis has the weight of evidence in its favor is apparent from two considerations. The object is enclosed in an ironstone concretion. Organic matter as a nucleus is frequently responsible for initiating the chemical and physical changes that produce concretions, as witness the well-known fossil-bearing nodules from Pennsylvanian strata on Mazon Creek, Illinois. Secondly, the structure of the fossil is apparently not correlatable with any produced by inorganic processes.

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[1] Bequaert, J. C., and Carpenter, F. M. *The antiquity of social insects.* Psyche, vol. 48, pp. 50-55, 1941.

[2] Brown, Roland W. *The comb of a wasp nest from the Upper Cretaceous of Utah.* Am. Jour. Sci., vol. 239, pp. 54-56, 1941.

Inasmuch as *Celliforma favosites* is definitely from Upper Cretaceous strata, and as no social Hymenoptera themselves have yet been reported from strata older than Eocene, Bequaert and Carpenter (p. 50) intimate that such evidence suggesting the existence of the social habit among insects in Cretaceous time should be received with great reservations. Do these writers support the idea that the social habit appeared suddenly by accident, or special creation, and was not the result of a long, gradual evolution? Moreover, relatively little is known of Cretaceous insect life as compared with that of the Eocene, so that the discovery of a Cretaceous social insect is by no means precluded.

"The counterpart of the fossil is lined by shallow cavities which fit over the ends of the projections. One portion of this counterpart also has projections like those on the other half, so that when the parts of the concretion are placed together, the dome-shaped projections extend inwards from both sides. This extraordinary condition, which is not mentioned by Dr. Brown, seems to require an explanation, if the specimen is regarded as a nest" (p. 51). The portion of the counterpart referred to is at one end of the specimen, near the margin, and it is only in this portion that the condition described occurs. Have Bequaert and Carpenter never seen disintegrating nests in which portions around the margin of the comb are loose and turned back in inverted position on the main portion of the comb? Instead therefore of discrediting the fossil as a wasp nest, the recognition of this condition, it seems to me, is distinctly a positive contribution toward certainty of the original identification.

My critics chide me gently for leaving "to the reader the pleasure of speculating as to the circumstances and method by which the original comb became this fossil" (p. 51). Nevertheless, despite the fact that "the method by which a wasp nest might be preserved so as to resemble the fossil in question is very difficult to imagine" (p. 51), they accept my invitation and supply a probable version of the process. Their chief difficulty, although they admit they have not experimented with nests, is to see how it would be possible for a paper nest to retain its shape long enough to permit the mud and sand contents of the cells to become so hard as to retain its form after the disintegration of the paper walls. "The thin, soft walls between the cells would, in our opinion, inevitably disappear within a short time long before the foreign material could harden" (p. 51).

Obviously I do not know whether the postulated original nest hung from a tree, rock, or other support, or was a subterranean structure. Neither have I any information as to its topographic location; its proximity to a stream or other body of water; nor the conditions at the site of entombment whether on land or in water. These are the "circumstances" I had in mind when inviting the reader of my paper to speculate. As to the difficulties alleged by Bequaert and Carpenter in imagining a method of fossilization, it may be pointed out that if the cells of a papery nest were quickly buried in fine mud and sand so that pressure would be equal in all directions there would be little likelihood under normal conditions for much distortion of the cells, and the paper walls could conceivably serve as partitions for a long time, particularly if the paper were first partly carbonized or lignitized, as would very likely be the case in a comparatively short time. Something of this nature probably occurs during the fossilization of wood. Contrary to most statements in textbooks about "replacement atom by atom of carbon by silica," silicification of wood is essentially a process of infiltration and deposition of silica in the cells, and only secondarily one of replacement. The delicate cell walls generally remain carbonized as is shown by the fact that peels displaying the cellular structure as a deposit of carbon can be pulled from sections of the wood appropriately treated with hydrofluoric acid. Those who have seen fossil wood in which the minute details of anatomy are exquisitely preserved without distortion, or many other fragile structures of plants and animals equally well-preserved, need no further persuasion that fragility of the original object is necessarily a bar to perfect preservation provided other conditions are right.

Bequaert and Carpenter remark about the regularity and perfection of preservation of all the cells in the fossil, and suggest that, in view of the fragility of paper nests such regularity would seem impossible to be attained; and that if only a few cells were so preserved the identification of the fossil as a wasp nest would seem more plausible. The answer to this contention is that the fossil is apparently only a small portion of what was very probably a large nest and that it represents a protected portion which escaped injury and disintegration during the process of getting entombed in the sediments. I have had part of a nest of *Polistes* in water for some days now and, although waterlogged, it still retains its shape and can with care be handled without much distortion, especially of the cells several rows inward from the margin.

Comparing the fossil with nests of living wasps Bequaert and Carpenter allege a number of discrepancies. Some of these criticisms are in part well-taken, but all seem to rest on the assumption that primitive social wasps had nest-building habits that must have been exactly like those of living wasps. Such a rigid interpretation of the law of uniformity, although perhaps applicable to inorganic processes, does not seem appropriate for organisms. Without variation there can be no evolution of organisms or their habits.

In the fossil the dome-shaped projections representing the bottoms of the cells are arranged in parallel rows in three different directions. In the nests of living wasps, however, according to Bequaert and Carpenter, although the open ends of the cells may show such regular arrangement, the bottoms or closed ends are irregularly arranged, particularly as may be seen when the paper cover is removed. In all nests I have examined the paper surface covering the bottoms of the cells displays parallel rows of cells in three different directions with the same degree of regularity as the open ends of the cells. This is well-illustrated by figures

246, 248, and 249 in Duncan's[3] recent publication on vespine wasps. Irregularities such as tapering and curving of the bottom portions of the cells is common around the margin of the comb, and probably varies considerably with different species. Sections cut carefully along a row of cells through the central part of a comb usually show as much regularity of cell bottom arrangement as that in the fossil. See Duncan's figure 212.

The dome-shaped cell bottoms shown in Duncan's figure 212 will also serve to refute the statement that "the bottoms of the cells of vespid nests are not dome-shaped, as in the fossil, but are flattened or angular." It is true that around the margins of the combs of most nests the cell bottoms are flat or angular; but this is not true for all parts of the comb or for all conditions. The bottoms of most cells in long-abandoned nests are filled with irregular fecal pellets or other debris. In combs where remnants of the silk cocoons spun by the larvæ still line the cell walls and cover the fecal pellets deposited by previous inhabitants the bottoms of the cells are perfectly dome-shaped as may be seen in a nest of the common hornet, *Vespa* (=*Dolichovespula*) *maculata*, now in my possession.

The statement that the heights of the dome-shaped projections on the fossil are "remarkably uniform" is an unwarranted exaggeration. The degree of irregularity in height is as great as any observed in the nests of living wasps. To the criticism that the cells of vespid nests taper, being wider at their openings than at their bases, whereas in the fossil the cells have a constant width, the reply is that the degree of tapering varies from nothing to very considerable proportions in different nests and different species.

"In the fossil the substance between the cells is nearly as thick as half the diameter of the cells" (p. 53). This measurement was evidently estimated by looking down upon the dome-shaped projections of the fossil and noting the yellowish clay lying between the bases of adjacent domes. This extraneous material, however, is no indication whatever of the thickness of the original vertical cell walls, but may be a replacement of thickened portions of the paper over and between the bottoms of the cells. The true thickness becomes apparent at once in a vertical section where it can be seen as a paper-thin, yellowish deposit between adjacent cells.

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[3] Duncan, Carl D. *A contribution to the biology of North American vespine wasps.* Stanford Univ. Pub., Biological Sciences, vol. 8, no. 1, 1939.

Although Bequaert and Carpenter reject my specimen as the comb of a wasp nest, they do not, as stated, deny that it is a fossil. However, they offer no suggestion as to its probable identity except to point out a resemblance to nests called *Uruguay auroranormai* described by Roselli.[4] It appears from Roselli's description that these nests were taken from Cretaceous strata in Uruguay, but the evidence is not clear that they were made in Cretaceous time. However this may be, the resemblance between *Celliforma favosites* and *Uruguay auroranormai* is only superficially suggestive. The cells of both nests are arranged in parallel rows in three different directions. Those of *U. auroranormai* are larger, and it is quite evident from Roselli's figures 19, 20, and 31, that the cells are separated from one another by matrix approximating in thickness one-third the diameter of the cells. In *C. favosites* the cells, as stated before, are separated from one another by a thin deposit of paper thickness only. Roselli's figure 20 shows one cell that displays a spiral seal,[5] a circumstance which indicates strongly that the constructor of the cell was a mining bee rather than a wasp.

For the reasons given I am not convinced that the Bequaert and Carpenter arguments rule out the possibility of a vespine, or in broader terms, a social hymenopterous origin of the fossil. I would, however, make it clear that I am open-minded on the issue and am ready to accept satisfactory evidence, no matter what the result may be.

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[4] Roselli, F. Lucas. *Sobre insectos del Cretaceo del Uruguay o descubrimientos de admirables instintos constructivos de esa epoca.* Boletin de la Sociedad Amigos de las Ciencias Naturales "Kraglievich-Fontana", tomo 1, num. 2, pp. 72-102, 1938.

[5] Brown, Roland W. *Celliforma spirifer, the fossil larval chambers of mining bees.* Jour. Wash. Acad. Sci., vol. 24, pp. 532-539, 1934.

PERIPATUS (MACROPERIPATUS) GEAYI IN PANAMA

By Charles T. Brues

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As the Caribbean islands and adjacent mainland have been more carefully explored by zoologists interested in terrestrial invertebrates, information on the distribution of Onychophora in this area has slowly accumulated. A quite considerable number of species are now known to occur there, but as these animals are by no means abundant, the geographical range of the several species is poorly known.

I have recently received from Dr. Ralph Buchsbaum a specimen from El Cermano, near the west coast of Panama, north of Panama City. It is one of a series of five obtained for him by a friend of Mr. James Zetek. Dr. Buchsbaum had them under observation and they served him as subjects for some remarkably fine colored motion pictures as well as for black and white photographs.

This species is *Macroperipatus geayi* described by Bouvier in his "Monographie des Onychophores" in 1907 from the coast of Guiana. It was later reported from Panama by Clark[1] on the basis of a specimen from La Chorrera. The present writer recorded it from the Santa Marta Mountains, Colombia[2] on the basis of two collections.

As the color of all the Neotropical species fades rapidly in alcohol, Bouvier was unable to ascertain the color of *M. geayi* in life, and noted no conspicuous pattern. Clark mentions "a broad, transverse, obscure yellow band" just behind the head. The specimens seen by me from Colombia also possessed the pale band or "necktie," with one exception. In the living ones observed by Dr. Buchsbaum the band is cream colored, but soon fades to nearly white in alcohol. The general body color is red brown or rust colored. Morphologically it seems certain that there are no specific differences between the type and the gaudily marked Panamanian specimens. Dorsally the body bears lozenge-shaped marks, very distinct in contracted individuals, but much less noticeable when the body is extended. A similar conspicuous band is present in at least two other Caribbean forms, *Macroperipatus torquatus* Von Kennel and *Peripatus manni* Brues, as well as in the Andean *Oroperipatus peruvianus* Brues.

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[1] Smithsonian Misc. Coll., vol. 60, no. 17, p. 2 (1913).

[2] Psyche, vol. 32, p. 160 (1925).

A NOTE CONCERNING AGGREGATIONS OF *Ululodes villosa* BEAUVOIS.

On June 15th, 1940, I was collecting dragonflies along the little Jicomé river in the lower valley of the Yaque del Norte in Santo Domingo. While wading in the streambed below the highway bridge (Km. 214, Monte Christi road), and crowding my way between some bushes that overhung a riffle at a narrows, I disturbed a company of these big brown Ascalaphids. A chance stroke of my net against the bushes flushed several dozen of them. They fluttered, butterfly-like, around my head for a few minutes, and then settled again on twigs overhanging the water.

Later, in the mountains near San Jose de las Matas I flushed another colony from the pendant low-hanging bough of a large tree where it overhung the riffle in the Iguamo river. These also fluttered about wildly for a time, and then reassembled on the same boughs, quite disappearing from view in the process.

JAMES G. NEEDHAM.

THE INTER-RELATIONSHIPS OF CERTAIN JASSOID GENERA (JASSOIDEA, HOMOPTERA)

By J. W. Evans

Department of Agriculture, Hobart, Tasmania

As a result of a study of Australian leaf-hoppers which has extended over several years, certain conclusions have been reached concerning the classification of this group of insects that disagree with the generally accepted ideas on the subject. These conclusions have already been published (Evans, 1939). The purpose of the present paper is to draw attention to the new proposed classification in so far as it affects certain genera represented in the North American fauna. It is not intended to repeat the arguments on which the new system is based, nor to give lengthy diagnoses of characters. Instead, recourse is made to brief comparisons supported by illustrations. These it is hoped will suffice to stimulate interest in the new proposals, and help to pave the way to a system based more on genetic affinity than on superficial characteristics.

The genera concerned are, Bythoscopinae: *Bythoscopus* Germ., *Agallia* Curtis, *Idiocerus* Lewis, *Macropsis* Lewis, *Oncopsis* Burm., *Neopsis* Oman; Gyponinae: *Gypona* Germ., *Penthimia* Germ., *Xerophloea* Germ.; Jassinae: *Jassus* Fabr., *Euscelis* Brullé, *Dorycephalus* Kirsch., *Hecalus* Stål, *Spanbergiella* Sign., *Parablocratus* Fieb., *Nionia* Ball; Koebelinae: *Koebelia* Baker.

Following Baker (1923), it has been found convenient to regard each of the more distinct groups of leaf-hoppers as a family unit, and the re-arrangement of the above genera into families on the basis of my system results in the following groupings:

Bythoscopidae	Gyponinae	Hecalini —	*Hecalus, Parablocratus, Spanbergiella*
		Gyponini —	*Gypona*
	Bythoscopinae		*Bythoscopus*
	Penthimiinae	Penthimiini —	*Penthimia*
		(Thaumatoscopini*)	

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*Not represented in North America.

Euscelidae, *Euscelis*. Agalliidae, *Agallia*. Macropsidae, *Macropsis*, *Oncopsis*, *Neopsis*. Idioceridae, *Idiocerus*. Jassidae, *Jassus*. Thymbridae, *Nionia*. Ledridae, *Dorycephalus*, *Xerophloea*. Stenocotidae, *Koebelia*.

Whilst certain of the proposed changes, such as the separation of *Euscelis*, *Idiocerus* and *Jassus*, have been suggested previously by other workers, others, in particular the association of *Bythoscopus*, *Hecalus*, *Penthimia* and *Gypona*, are original, and may at first sight appear absurd. If in time the alterations proposed should become accepted in whole or even in part, it will not be the first occasion on which a knowledge of the Australian representatives of a group of organisms has led to a radical change being effected in the basic classification of the same group in other faunal zones.

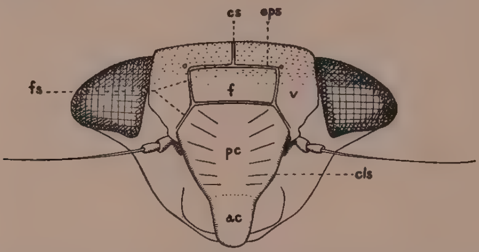

Figure 1. Head of a nymph of *Tartessus* sp. ac., ante-clypeus; pc., post-clypeus; f., frons; cls., clypeal suture; fs., frontal suture; v., vertex; cs., coronal suture; eps., epicranial suture.

The usual arrangement of the various genera into subfamilies on the basis of the position of the ocelli is clearly artificial and several workers have stressed this fact in the past. Nevertheless, whilst the position of the ocelli may be of little significance, the shape and structure of the head as a whole affords the most reliable single diagnostic character. Because certain terms will be used in referring to the head that are not commonly employed, a figure of the head of a nymph of *Tartessus* sp. is given with certain of the sutures and sclerites indicated (Fig. 1). This particular insect has been chosen for illustration as the front is present as a separate sclerite. With the backward migration of the dilator muscles of the sucking pump, the epistomal suture, which separates the clypeus from the frons, disappears;

such a condition is found in all adult leaf-hoppers. The sclerite made up in part of the frons and in part of the post-clypeus, will be referred to as the fronto-clypeus. It may be entirely central in position or extend onto the crown, and may, or may not, be directly continuous with the vertex. The morphology of the head of Homoptera has been fully discussed in three recent publications (Spooner, 1938; Evans, 1938; Snodgrass, 1938.)

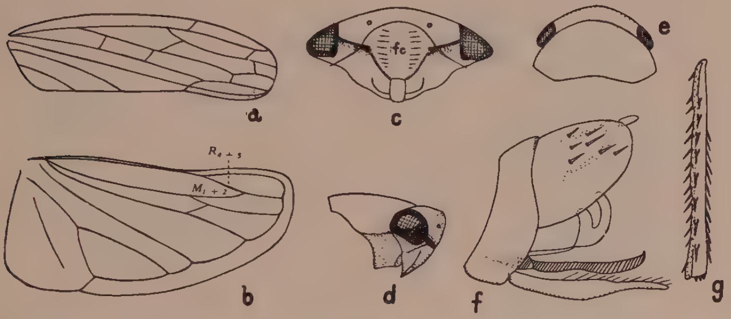

Figure 2. a, b, e, *Eurinoscopus punctatus;* c, d, g, *Bythoscopus lanio*; f, *Eurinoscopus* sp., male genitalia; fr., fronto-clypeus.

BYTHOSCOPIDAE

The principal features of the external structure of *Bythoscopus lanio* (L.) and *Eurinoscopus* spp. are shown in Figure 2. *Eurinoscopus* Kirk. is an Australian genus which according to Oman (1936) is synonymous with *Bythoscopus*. In Figure 3 the corresponding parts of *Reuteriella flavescens* Sign. are illustrated. This is an Australian leaf-hopper, which, because of the marginal position of the ocelli, would presumably be placed in the Jassinae by most Hemipterists. It is unnecessary to do more than draw attention to the very close similarity between the two groups of illustrations. The differences are, that in *Bythoscopus,* a frontal and an epicranial, but not a coronal, suture are retained, the reverse being the case with *Reuteriella.* The ocelli in the two genera are in identical positions, as is shown by a comparison of Fig. 2, d with Fig. 3, e, except that the backward extension of the muscles of the sucking-pump and the accompanying flattening and production of the head have changed their aspect in *Reuteriella.*

The process arising from the ventral internal margin of the pygophore of the male genitalia of *R. flavescens* is secondary, and of only specific value as a diagnostic character. Quite apart from structure, in appearance, habits and coloration, *Reuteriella* spp. and *Eurinoscopus* spp. are very similar.

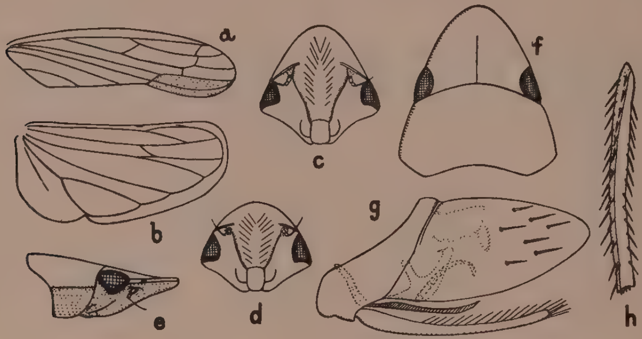

Figure 3. *Reuteriella flavescens;* c, ♀; d, ♂.

If it is accepted that *Reuteriella* should be grouped with *Bythoscopus* rather than in the Jassinae, there seems to be no good reason why *Hecalus, Parablocratus* and *Spanbergiella* should not also be placed in the Bythoscopidae. Although species in these genera may lack the character of having R_{4+5} fused apically with M_{1+2} in the wing, all have similarly shaped heads and pronota and flattened hind tibiae with an almost identical armature of spines. Furthermore, the tegminal venation is not basically dissimilar. Figures are given (Fig. 4, d–g) of *Spanbergiella vulnerata* (Uhl.) and *Parablocratus glaucescens* Fabr. (a Tunisian species).

The relationship of *Gypona* to *Bythoscopus* is not quite so apparent, but it is believed that *Krisna strigicollis* (Spin.), which occurs in Borneo (Fig. 5 a–e), is close to *Reuteriella.* A comparison of these figures with Figure 5 a_1–d_1 suggests that the two genera are not far removed from each other. Moreover, if *Penthimia* is grouped with *Gypona,* as is usually done, then the case for the inclusion of *Gypona* in the Bythoscopidae is strengthened. A comparison of the head of

Bythoscopus and *Penthimia*, illustrated in Figures 2, c and 4, b respectively, will show that the genera resemble each other in essential head structure. The occurrence of the hindmost part of the fronto-clypeus on the crown in *Penthimia* is a purely secondary feature brought about by the production and inflation of the fronto-clypeus. The Thaumatoscopini are a tribe comprising Australian genera that show complete gradation between species with ventral ocelli and rounded heads, and others with dorsal ocelli and spatulate heads.

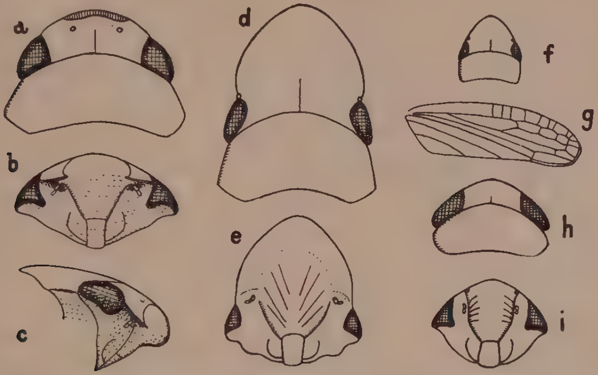

Figure 4. a–c, *Penthimia americana;* d, e, *Spanbergiella vulnerata;* f, g, *Parablocratus glauscens;* h, i, *Thamnotettix cockerelli.*

EUSCELIDAE

This family, which comprises genera related to *Euscelis*, such as *Thamnotettix* Zett., *Eutettix* Van D. and *Deltocephalus* Burm., though distinct from the Bythoscopidae, is probably an offshoot from it. It is almost certain that *Hecalus*, *Parablocratus* and *Spanbergiella* are nearer to *Bythoscopus* than to *Euscelis*. For the purpose of comparison, figures are given of *Thamnotettix cockerelli* Ball. (Fig. 4, h, i).

AGALLIIDAE

Agallia does not closely resemble *Bythoscopus* in shape, size, or coloration, nor in a single character of any significance; neither do any of the numerous genera usually associated with *Agallia*. For comparison with the illustrations of *Bythoscopus*, figures are given of *Euragallia farculata* (Osb.) (Fig. 6, g–i).

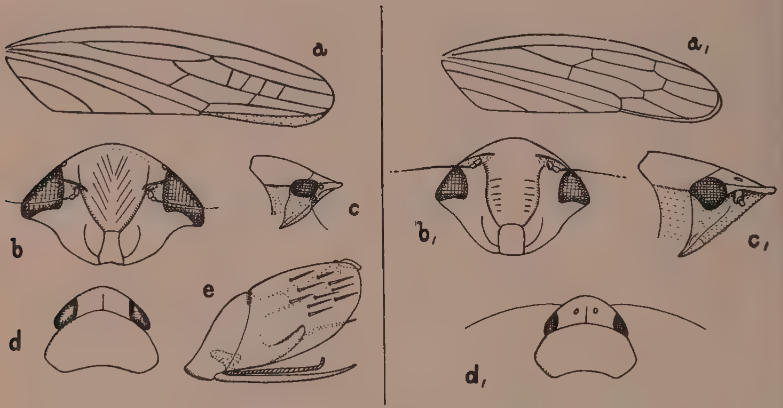

Figure 5. a–e, *Krisna strigicollis;* a, *Gypona scarlatina,* b–d, *Gypona 8-lineata.*

MACROPSIDAE

Macropsis and *Oncopsis* likewise present no essential features in common with *Bythoscopus*. Oman (1936) has suggested that *Neopsis* Oman is intermediate in character between *Macropsis* and *Bythoscopus*. Through the kindness of Mr. Oman I have been able to examine a specimen of the genotype, *N. elegans* Van D., and am of the opinion that without any doubt it should be placed in the Macropsidae, any resemblance it may have to *Bythoscopus* being purely superficial. All the Macropsidae have a character in common that does not occur in representatives of other families. This is, that when the muscle impressions of the sucking-pump are visible on the fronto-clypeus, they are invariably confined with a pair of crescent-shaped markings.

IDIOCERIDAE

In 1936 Oman removed *Idiocerus* and related genera from the Bythoscopinae and referred them to the Eurymelinae. Whilst in agreement with the separation, I do not support the new combination. The following characters which occur in all the Eurymelidae are not found in *Idiocerus*: in the head the epicranial sutures are invariably retained; in the tegmen the media has always two, and sometimes three, distinct branches; in the male genitalia the aedeagus is not in direct contact with the basal plates. Quite apart from these features, the Eurymelidae differ from the Idioceridae in shape, coloration and habits. Figures of *Idiocerus dolosus* Ball (Fig. 6, d–f), are given for comparison with those of *Bythoscopus*.

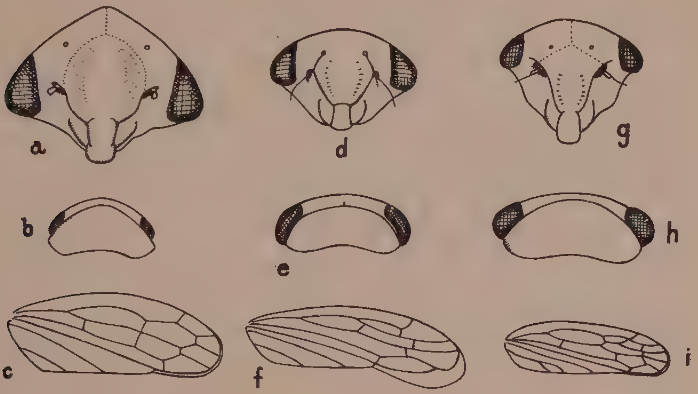

Figure 6. a, *Macropsis tasmaniensis*; b, c, *Oncopsis distinctus*; d–f, *Idiocerus dolosus*; g–i, *Euragallia furculata*.

JASSIDAE

Figures are not given of a representative of this family, but there seems no good reason why genera such as *Jassus* Fabr. and *Tharra* Kirk. should be associated with forms such as *Euscelis* and *Thamnotettix*.

THYMBRIDAE

Oman, in referring to *Nionia* Ball, states that it was correctly placed by Ball as a relative of *Tartessus* Stål, but was more closely related to *Thymbris* Kirk. and *Epipsychidion* Kirk. I have not had an opportunity of examining a specimen of *Nionia*, but, if it is closely related to *Thymbris*, it is presumably a member of the Thymbridae, which contains several Australian genera and a single New Zealand genus. Thus it cannot be very close to *Tartessus*. The Tartessidae contain a number of genera which now occur in Australia, New Guinea, the Phillipines, New Caledonia and Mysol and which all have certain unique characteristics. One of these is the continuation of the ambient vein of the wing onto the anal area. The tegmen of *Mesojassoides gigantea* Oman from Cretaceous deposits of Colorado figured by Oman (1937), is very similar to that of a present-day *Tartessus*, and suggests that this family had a wider distribution at one time than it has at present.

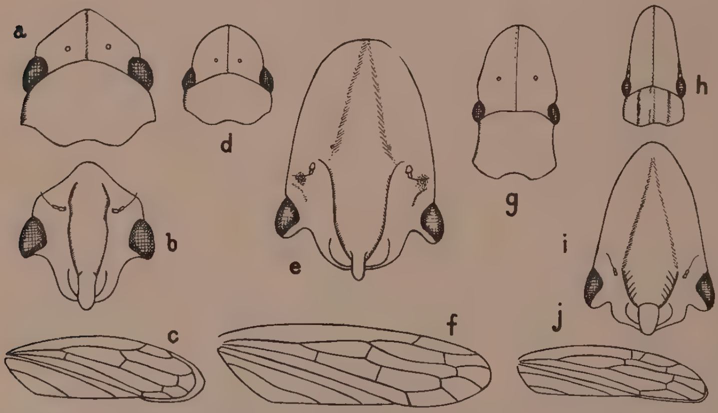

Figure 7. a–c, *Xerophloea viridis*; d, f, *Rubria sanguinea*; e, g, *Ledropsis crocina*; h–j, *Dorycephalus platyrhynchus*.

LEDRIDAE

Xerophloea is usually placed in the Gyponinae because it has dorsal ocelli and is clearly not close to *Cicadella* Latr., *Dorycephalus* having marginal ocelli is placed in the Jassinae. Both genera are much closer to genera in the Ledridae, as may be seen in Figure 7, where figures of the Australian Ledrids *Rubria sanguinea* Stål and *Ledropsis crocina* Dist. are placed beside others of *Xerophloea viridis* (Fabr.) and *Dorycephalus platyrhynchus* Osb.

STENOCOTIDAE

Baker (1923) considered *Koebelia* to be intermediate between *Ulopa* Fall. and *Paropia* Germ. on the one hand, and *Stenocotis* Stål on the other. For reasons previously given, (Evans, 1939), there would seem to be no justification for placing *Koebelia californica* Baker in a separate family, when it is essentially a Stenocotid.

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